FAMOUS MEN OF SCIENCE

SARAH K. BOLTON

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JEAN HENRI FABRE
From a photograph

FAMOUS MEN OF SCIENCE

BY

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PREFACE

Garfield once said, "No page of human history is so instructive and significant as the record of those early influences which develop the character and direct the lives of eminent men."

These sketches show how young men have overcome difficulties, sometimes poverty, sometimes illness; how they have made failures before finding their true vocation. They show the results of energy, perseverance, and untiring devotion; as, for example, how Carl Linnæus fought his way up through poverty to a chief place among the botanists of all time; how Herschel seized time off from his music teaching to construct his own telescopes and discover new worlds in space. They show how a cheerful face and a hopeful spirit like Agassiz's, or a gentle and kindly nature like Darwin's, can win its way against opposition.

"Famous Men of Science" was first published in the year 1889, and has been repeatedly reprinted since that time. The present edition (1926) has been entirely revised and reset and several additional chapters added. In its new dress it is a much more comprehensive work, including the life stories of famous scientists from the days of Copernicus down to the present. The biographies are arranged in chronological order, so that the reader is guided, as it were, along the main highways of scientific research for the past four centuries.

Among astronomers we have Copernicus, Galileo and Herschel. Among physicists, Newton, Davy, Faraday and Kelvin. Among exponents of natural history, Cu-

vier, Audubon, Agassiz, Von Humboldt, Darwin, Fabre, and Huxley. Among bacteriologists, Pasteur. Among botanists and geologists, Linnæus and Lyell. This classification is only general, as the reader will discover that these men were many-sided. They were often interested in several fields coincidentally, and their contributions to exact knowledge were varied.

This book, however, is not so much a record of fact as a series of portraits. As in her other "Famous" books, Mrs. Bolton is concerned primarily with the human side of her subjects. She is interested in tracing the development of a great life from its small and obscure beginnings, and revealing the secret of its success. Mrs. Bolton was a widely traveled and widely read woman. She brings to bear a rich fund of anecdote and description to enliven her pages. These, with her constant vein of sympathy, go far to explain the enduring success which she has achieved in this particular type of biography.

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FAMOUS MEN OF SCIENCE

NICOLAUS COPERNICUS

Carlyle once remarked that the history of the world is the history of its great men; one might with equal truth state that the history of astronomy is a record of the lives of the great astronomers. Just who was the first astronomer must remain forever unknown;[1] but it is certain that in the very beginning of mankind astronomy received attention. And the reason is not far to seek: some knowledge of the subject was necessary to fix the dates for the celebration of the various fasts and festivals—a matter of paramount importance throughout medieval times. It is probable that all the early scientists studied the heavens merely as a side line. Thus, Aristotle, who exercised such a profound influence in this branch of learning, was both an all-round scientist and a philosopher. Claudius Ptolemy, one of the most famous of the ancient astronomers, was an Egyptian king, who reigned at Alexandria between 127 and 157 A.D. Ptolemy's theory, that the earth was immovable and the center of the universe, round which revolved in order the Moon, Mercury, Venus, the Sun, Mars, Jupiter, Saturn, and the stars proper, was so entwined with matters of the Church

[1] This distinction is frequently credited to Hipparchus, who was born about 170 B.C. He made a catalog of the positions of the stars, and was spoken of by Ptolemy, some 200 years later, as a "most truth-loving and labor-loving man."

and Scriptures that it remained absolutely unquestioned for fourteen hundred years, and when Nicolaus Copernicus, himself many things besides an astronomer, became satisfied that the theory was false, he yet dared not denounce it for a long time, knowing full well the charges of heresy which would engulf him. The proclamation and proof of his discovery ushered into the world a new era of philosophical belief, and today to be the Copernicus of any movement is at once to align oneself with honesty and freedom of thought, mind, and conscience, the while paying tribute to an old monk who lived a life of solitude in the monastery gardens at Frauenburg some four centuries ago.

Nicolaus Copernicus was born in the town of Thorn, on the Prussian frontier, February 19, 1473. His father was a successful tradesman; his mother was a sister of Lucas Watzelrode, Bishop of Ermeland—a relationship which proved very advantageous to the nephew when he had attained man's estate and begun to exercise indications of a great mind and unusual research abilities.

But little is known of the youth Nicolaus, beyond the fact that he seems always to have been of a sober turn, taking naturally to books and absorbing Latin and Greek as readily as a sponge does water. We are told that his education was carried on at home until he was able to enter the University of Cracow, with the idea of training for the medical profession. Here, however, an aptitude for mathematics and natural philosophy was uncovered, and shortly Nicolaus was so deep in all three subjects that a fourth needs must be developed to carry the others to completion, and he became an expert draughtsman.

Having graduated from Cracow in both arts and medicine, he set himself up in Rome as an earnest mathematician and astronomer, and was soon so well and favorably known that he was honored by the offer of the chair

of mathematics in the University of Rome. But he was not long to occupy this position. His uncle, the Bishop of Ermeland, had kept a gratified eye upon the young man's progress, and now desired to have him identified with the homeland; so he offered him the canonry of the cathedral at Frauenburg.

Believing that some further preparation was necessary for the successful fulfillment of this trust, Copernicus entered the medical department of the University of Padua, where he remained until 1505, and then was stationed at the palace of Heilsberg for further preliminary service as the Bishop's private physician. Here he found life far from a bed of roses. Resenting what in modern parlance would be considered "his pull," envious folks did all in their power to make matters unpleasant for the young prebendary-to-be. Such was the natural gentleness of Copernicus, his love of peaceful solitude, and his unquestioned scholarship, however, that animosity could not endure, and on his uncle's death he found himself in unquestioned possession of the canonry, and held in deepest reverence and respect. Here he fell into a daily round which was characteristic of the mathematical man of precision: Carefully dividing his time into thirds, he gave his day (1) to devotional exercises and diligent performance of his divine duties; (2) to charitably tending the sick poor in need of medical attention; (3) to the pursuance of his hobby—the study of astronomy and philosophical meditation.

That Copernicus wielded no small influence among his parishioners is proved by the fact that he was frequently called upon for advice in affairs of state, and though he never went out of his way to seek political honors, he was always ready and willing to give from his store of wisdom and learning for the benefit of his country. Thus, when the many wars shook the financial standards and

the Diet could not satisfactorily settle the question of money, a committee of senators was appointed to investigate affairs, and in turn, owning themselves powerless to cope with the problem, appealed to Copernicus. He set himself at once to the gigantic task, and presently evolved a plan for reducing to a definite standard the various moneys then in circulation in the provinces of the kingdom, at the same time getting out a valuable circular on money generally. His pamphlet was eagerly published, and his plan immediately adopted by the senate, who gratefully inserted it in their public Acts.

One of the chief instruments in the modern observatory is a transit telescope. It is so mounted that it can swing only on the plane of the meridian, and therefore, sooner or later in the course of every twenty-four hours, all stars must cross its path, the time of their so doing being of particular moment in determining certain astronomical data. Copernicus had no transit instrument; in fact, he had no notion whatever of a telescope of any kind, as the invention of this important device did not occur until more than seventy-five years after his demise. But in the days of the old monk as now, necessity was the mother of invention, and the mind of Copernicus was quite equal to coping with the problem: he had slits cut in the walls of his observation room, and by placing himself suitably, was thus enabled to note the transit of the stars across a prescribed meridian. Further, by means of a quadrant of his own making, he succeeded in measuring the altitude of various stars above the horizon.

From the very first, Copernicus was interested in the movement of the planets, and the tables which he compiled were accounted the best of his times, and remained in use long after he himself had passed away. In making some special studies of the planet Mars, the old monk was much impressed by the variability of the brightness

and magnitude of this planet at different times. Why was this? He turned to the Ptolemaic system for the answer. Briefly speaking, this theory held the earth to be immovable, and that the planets, sun, moon, and stars, while not exactly revolving directly around it, yet revolved around imaginary points which in turn revolved round the earth in a circular path known as the deferent circle. The whole comprised a most complex puzzle which few rightly understood, and the more Copernicus pondered the less satisfied he became. Was it possible that Nature who always did things by the simplest methods had concurred in this ponderous scheme of circles? Had he not been so deeply religious, it is probable that, like Alphonso X, King of Castile, Copernicus might have felt that, if the theory were true, had he been "consulted at the Creation he could have given some useful hints!"

Instead, his dissatisfaction only made him doubt the more, and he turned to the records of science for support in what he considered must be the real facts of the case, viz; that *the sun* and not the earth was the center of our solar system, and that it was the rotation of the earth on its axis which caused day and night, and the revolution of the earth about the sun which brought about the change of the seasons. Others he soon found had set forth much the same belief. Two thousand years before, Pythagoras, a Greek philosopher, had voiced the opinion that the sun was the center of the planetary system, and one of his followers, Aristarchus, who lived some four hundred years before Ptolemy, had suggested the rotation of the earth to account for the diurnal motion of the heavens. Both, however, had been overborne by Aristotle and Ptolemy, who had contrived to get their own strong beliefs backed by the Roman Church. It was preposterous, Ptolemy had held, to think of the earth in rotation. If such were the case, the rush of atmos-

phere would sweep men off the surface. Copernicus answered in his own mind by saying that the inhabitants would be carried by the earth in the same manner as a man carries his overcoat. Besides, would it not be much simpler for the earth, along with the other planets, to revolve round the sun, in an orbit between Venus and Mars, than for the whole system of intricate circles to revolve round the earth? If his supposition were correct, he added, Venus and Mercury should exhibit phases like the moon. But this point was not established until after Galileo's invention of the telescope had clinched the Copernican theory beyond a doubt.

How long Copernicus was convinced of his theory before he communicated it to others is a matter of some conjecture. He found difficulty in breaking away from the "circle-worship" of the old philosophers. Besides, who was he to voice an opinion so contrary to the Church and all established belief? Someway, however, a hint leaked out, and men of science, flocking to Frauenburg to learn the truth, went away fully satisfied that Copernicus had the right of the matter.

But still the old monk could not be persuaded to put his theory into print for the benefit of the world at large. Some of his reluctance was no doubt due to his strong loyalty to the Church and to his general retiring disposition; he disliked argument and controversy, and had small heart for facing all the stigma which would be attached to him for heresy. Besides, though he was entirely sure of the facts of the case, a good deal was based on supposition; he could not prove his theory, much less make a satisfactory diagram of the sun and planetary system: his head was muddled with epicycles—in those days it was thought that all motions must be compounded of circular ones, and he could not get clear from Ptolemy's idea of a deferent circle. It remained for Kepler in the

next century to make a clean sweep of the complicated system of circles and substitute for it the simple ellipse.

The great achievement of Copernicus, therefore, was that he served to put the earth in its proper place in the cosmic scheme. While others before him had opined that the sun was the center of things, this was of no particular moment, since they had failed in establishing their belief and even the record of it was well-nigh obliterated. In an age when the Church enforced its creed with an iron rigidity of discipline, Copernicus dared to take an opposing line, and to stand so firmly by his convictions before all those who challenged him, that eventually "Aristotle worship," which had impeded scientific progress for so many centuries, was effectively broken up, and the world emerged on a plane of free thinking that betokened the opening of a new era in things scientific.

And it was "The Revolution of the Celestial Orbs," the book in which Copernicus explained his theory, which ushered in this great dawn. For thirteen years the MS. had been ready, but now the author was too frail and full of years to undertake its publication, and it was accordingly taken to Nuremburg by his young friend and pupil, Rheticus, who won much distinction by the able manner in which he edited the work. But, such is the irony of fate, that while the first copy was on its way to the author, a paralytic stroke laid him low, and the book, the fruits of his long life, reached him only a few hours before his death, which occurred in his seventieth year. Copernicus was now beyond the power of the Church, but he had left behind a masterly plea in the shape of a "dedicatory note" to Pope Paul III, which was most pleasantly received by that dignitary:

"If there be some who, though ignorant of all mathematics," he wrote, "take upon them to judge of these, and dare to reprove this work, because of some passage of

Scripture, which they have miserably warped to their purpose, I regard them not, and even despise their rash judgment. . . . What I have done in this matter, I submit principally to your Holiness, and then to the judgment of all learned mathematicians. And that I may not seem to promise your Holiness more concerning the utility of this work than I am able to perform, I pass now to the work itself."

As for that work, the scientist of today who has been used to reverence the name of Copernicus learns with surprise "how much of error, unsound reasoning, and happy conjecture" the pages comprise. It remained for Kepler, Galileo, and Newton to rectify the blunders and mature the general theory. In the meantime, Copernicus was laid to rest in the Cathedral of Frauenburg, and so little was his service then appreciated that no mention of his great discovery was made on his tombstone, and indeed not until thirty years thereafter was any memorial erected to his memory.

Copernicus was a man of many talents, not the least of these being that he was an artist of considerable repute. In his early days, he painted a half-length portrait of himself, which later fell into the hands of Tycho Brahe, the poet and astronomer, who delightedly placed it in his museum above the following clever inscription and eulogy:

> Phœbus no more his bounding Coursers drives
> Sublime in Air; the task to Earth he gives.
> Amidst the world enthron'd he sits in State,
> And bids the Heav'ns obey the Laws of Fate;
> Yet thro' all Nature is his Aid the same,
> And changing Seasons still his Guidance claim.
> Erratic Stars have now their Courses known,
> By this rare System of the station'd Sun;
> They stand, go retrograde, are swift, or slow,
> Just as the Earth directs them what to do.

NICOLAUS COPERNICUS
From a portrait in the Royal Society

GALILEO GALILEI
From an early print

The great Copernicus (the Man behold),
This heavy Orb in rapid Motion roll'd.
But why, you'll say, was not his Wit portray'd?
But that is partly in the Heav'n display'd,
Partly in Earth; for neither can confine
The boundless Searches of his daring Mind.
Again you'll say—But half his Figure's shown,
A Man so worthy to be wholly known.
True; yet 'tis he who bore the Earth entire
Thro' Space immense around the Solar Fire;
The spacious Earth in vain would hold the Man
Who measures Heaven with his ample Span.

GALILEO GALILEI

"The same memorable day is marked by the setting of one of the most brilliant stars in the firmament of art and the rising of another in the sphere of science, which was to enlighten the world with beams of equal splendor. On the 18th of February, 1564, Michael Angelo Buonarotti closed his eyes at Rome, and Galileo Galilei first saw the light at Pisa."

Thus writes young Karl von Gebler, in the best life of Galileo ever written, his dying contribution to literature. Some other authorities place Galileo's birth on February 15.

He was the oldest in a family of five children born to Vincenzo Galilei, a Florentine noble, and Giulia Ammanati, who also belonged to an ancient family. Vincenzo wrote learnedly about music, and taught his boy to play on the lute and the organ; but he was poor and life was a struggle. However beneficial poverty may be in the development of character, most of us do not crave it for our children, so Vincenzo decided to place his son where he could earn a comfortable support. Music did not bring money. Galileo therefore should become a dealer in cloth; a necessity of life, rather than a luxury.

But the boy soon showed great skill in music, surpassing his father. He excelled in drawing and color, and could have become a noted artist. He loved poetry, and had a decided taste for mechanics, making machines of great ingenuity. It soon became evident that such a lad would not be satisfied to spend his life trading in wool.

He must be educated, but how? The family had moved

from Pisa, where there were schools of repute, to Florence. An effort had to be made, by the greatest economy, to prepare Galileo to go back to the Pisan University. He showed great aptitude for Latin and Greek, and at seventeen was ready for Pisa.

For what profession should he study? Not what best suited his tastes, but that in which his father thought he could make money, medicine. Poor Vincenzo! who can blame him that he hated poverty for his brilliant son?

At college, Galileo became an ardent student of philosophy, and because he dared to think for himself, and did not always agree with the teachings of Aristotle, he was called "the wrangler." Until he was twenty he was scarcely acquainted with the rudiments of mathematics, because his father thought this study was a waste of time for a man who was to become a physician. How many parents make the mistake of bending their children to their own plans, instead of ascertaining what a boy or girl can do best in the world, and then fitting him or her for it!

While Galileo was studying medicine in Pisa, boarding with a relative, the court of Tuscany came to the city for a few months. Among the suite was Ostilio Ricci, a distinguished mathematician, and Governor of the Pages of the Grand Ducal Court. He was a friend of the Galilei family, and was pleased to see the bright young son, Galileo. When he taught Euclid, the medical student would stand shyly at the schoolroom door, and listen with intense interest. Soon he began to study mathematics secretly; then begged Ricci to teach him, who gladly consented, till the father forbade it, seeing that Euclid interfered with medicine.

Meantime, the youth of nineteen, kneeling at prayers in the Pisa Cathedral, had dreamily watched a bronze lamp swinging from an arch. The oscillations were at first

considerable, but as they grew less and less, Galileo observed that they were all performed in the same time, measuring the time by feeling his pulse. The idea occurred to him that an instrument could be constructed which should mark the rate and variation of the pulse. He began to experiment, and soon invented the pulselogia, which the physicians hailed with great delight. The pendulum was not applied to clocks till a half-century later, but its invention attracted the attention of all scholars.

After four years' residence at Pisa, Vincenzo Galilei appealed to the reigning Grand Duke, Ferdinand de Medici, to grant to his son one of the forty free places founded for poor students, but the request was denied, and Galileo, unable to pay for his doctor's degree, was obliged to leave the university without it. Already he had learned bitter lessons of privation and disappointment, but youth has a brave heart, and looks ever toward the sunlight.

He went back to his home in Florence to study the works of Archimedes, whom he called his "master," to write his first essay on his Hydrostatic Balance, and to earn the reputation of a bold inquirer in geometrical and mechanical speculations. The father had now given up all hope of a fortune coming through medicine! Henceforward, the genius which was to shed lustre on his own name, otherwise buried in obscurity, was to have its own bent, and work out its own destiny.

If we are in earnest, a door opens sooner or later; but our own hands usually open it. At twenty-four a door opened to Galileo. Marquis Guidubaldo, a celebrated mathematician, appreciating what the young scientist had done, began a correspondence with him, and a valuable friendship resulted. The marquis asked him to study the position of the center of gravity in solid bodies.

Galileo applied himself to it, and wrote a valuable essay, which waited fifty years for publication. Perhaps no person can be really great who has not learned patience, and Galileo had many lessons in this virtue before he died.

Through the influence of the marquis, he was brought to the notice of Ferdinand I, reigning Grand Duke, who appointed him to the mathematical professorship at Pisa. This was a great honor for a young man of twenty-six, one who had been too poor to take his degree. The salary was small, less than a hundred dollars a year; but he earned somewhat by the practice of medicine, by lectures on Dante and other literary subjects, and by lessons to private pupils. Of course, he had little or no leisure; but he thus learned one of the most valuable lessons of life,—to treasure time as though it were gold. How glad his father and mother must have been that their wool projects had come to naught!

The professors at Pisa, with a single exception, Jacopo Mazzoni, in the chair of philosophy, were opposed to the newcomer. They were all disciples of Aristotle, and had not Galileo, when a boy among them, dared to oppose the great Grecian? And now, to make matters worse, he had taken some friends to the top of the Leaning Tower, and had put to the test the belief of two thousand years, —that the rate at which a body falls depends upon its weight. When the different weights fell to the pavement at the foot of the Leaning Tower, at the same time, the learned were astonished. If Aristotle could be wrong in one thing, he might in others, and this young man would revolutionize the teaching of the times!

The feeling became so strong against the investigator that after three years at Pisa he resigned. When will the world learn toleration for those whose opinions are different from the popular thought? From Galileo to Darwin we have persecuted the men and women whose views

were unlike our own in theology, in science, or in social matters.

Through his friend, the Marquis Guidubaldo, the mathematical professorship at Padua was obtained for Galileo. He was now twenty-nine, and becoming widely known throughout Italy. His father had just died, leaving the whole family, a wife and four children, dependent upon him for support; not a small matter for an ambitious and hard-working professor.

Padua gave the young man cordial welcome. Vincenzo Pinelli, a learned nobleman, who possessed eighty thousand volumes, mentioned him to Tycho Brahe, the great Danish astronomer, as a man whom it would be well to cultivate; but the Dane was too cautious about his own reputation, and did not write Galileo till eight years later and died the following year.

An associate of Tycho Brahe was wiser than his master, and sent Galileo his new book, "Prodromus Dissertationum Cosmographicum." A warm letter of thanks went back to the immortal John Kepler, saying: "Many years ago I became a convert to the opinions of Copernicus, and by that theory have succeeded in fully explaining many phenomena which on the contrary hypothesis are altogether inexplicable. I have drawn up many arguments and compilations of the opposite opinions, which, however, I have not hitherto dared to publish, fearful of meeting the same fate as our master Copernicus, who, although he has earned for himself immortal fame amongst the few, yet amongst the greater number appears as only worthy of hooting and derision; so great is the number of fools."

John Kepler, like Galileo, lived a pathetic life. His childhood was spent in the little beer-shop of his wretchedly poor father. At six he had a severe attack of small-pox, and his eyes were permanently weakened.

He was put to the plough, but his delicate body could not bear the work. At last, through charity, he became a theological student at Tübingen. But here he began to think for himself, and, probably, would have been obliged to leave the university.

Fortunately for science, he heard some lectures given by Michael Möstlen, famous in mathematics and astronomy. A new world opened to Kepler. He applied himself with all the ardor of youth, and at twenty-two became professor of mathematics at Grätz, in Styria. He was soon driven away from this Catholic stronghold, on account of his Protestant faith. Tycho Brahe heard of his needs, and made him his assistant at Prague, with a salary of seven hundred and fifty dollars a year. This seemed regal splendor to the poor astronomer. Now he studied the heavens with hope and delight.

But sorrows soon came. His children died, his wife became insane, and died also. The salary could not be paid, on account of the religious wars which convulsed Germany. He wrote almanacs, took private pupils, and in all ways tried to support his second wife and children, while he studied the heavens year by year, discovering his three great laws. The mathematical calculations for the first law, that the planets move in elliptical orbits round the sun, which is placed at one of the foci, filled seven hundred pages. His "Harmonies of the World" contained his third great law: "The squares of the periodic times of the planets are proportioned to the cubes of their mean distances from the sun."

Such was his joy when he discovered this law, after seventeen years of labor, that he said, "I have written my book. It will be read; whether in the present age or by posterity matters little. It can wait for its readers. Has not God waited six thousand years for one to contemplate his works?" In a last fruitless attempt to recover

twenty-nine thousand florins, owed him by the government, worn out with want and disappointment, he fell ill and died at Ratisbon, leaving thirty-three works, twenty-two volumes in manuscript, and his family in the direst poverty. Such was the man who admired Galileo in his youth, and who stands with him in the admiration of the generations that have come and gone since these two men lived and wrote and suffered.

At Padua, Galileo soon attracted great numbers to his class-room. Often a thousand gathered to hear his lectures, and when the hall was too cramped, he spoke to the people in the open air. He was above the middle height, well proportioned, with cheerful countenance, witty in conversation, and enthusiastic in his manner. So learned that he could repeat by heart much of the works of Virgil, Ovid, Horace, and Seneca; he was yet modest and unassuming, saying that he never met a man so ignorant but that something might be learned from him.

He labored incessantly. He wrote treatises on Fortifications, on Mechanics, on Gnomonics, on the laws of motion, on the celestial globe, which were copied by his pupils, and sent by them far and wide over Europe. He took a workman into his family, and began to superintend the making of the compass which he had invented, and the thermoscope, or heat indicator, which led in later years to the thermometer. His experiment was made by a "glass bottle about the size of a hen's egg, the neck of which was two palms long, and as narrow as a straw. Having well heated the bulb in his hands, he placed its mouth in a vessel containing a little water, and withdrawing the heat of his hand from the bulb, instantly the water rose in the neck, more than a palm above the level of the water in the vessel."

During the first six years at Padua, his salary rose from about one hundred dollars to five hundred dollars, yearly.

All this time, when his mind should have been free from care for his great work, he was beset with difficulties. His sister, Virginia, had married before his father's death, but a promised dowry had never been paid, and now the brother-in-law demanded the payment. The mother, worried over the prospect, wrote to her son, Galileo, "If you carry into effect your intention of coming here next month, I shall be rejoiced, only you must not come unprovided with funds, for I see that Benedetto is determined to have his own, that is to say, what you promised him; and he threatens loudly that he will have you arrested the instant you arrive here. And as I hear you bound yourself to pay, he would have the power to arrest you, and he is just the man to do it. So I warn you, for it would grieve me much if anything of the kind were to happen."

Livia, another sister, had become engaged to a Pisan gentleman, with the promise of a dowry of eighteen hundred ducats, eight hundred of which must be paid down. The "Pisan gentleman" could not burden himself with a wife, without funds to help support her and himself. So Galileo generously, if not wisely, borrowed six hundred ducats, and paid the necessary eight hundred, giving his sister beautiful clothes and house furnishings.

Besides these sisters, Galileo had a lazy brother to provide for, Michelangelo, a young man of some musical talent and elegant manners, with the not unusual gift of being able to spend much and earn little. Galileo obtained a situation for him with a Polish prince, and spent two hundred crowns in getting him ready for the new position. He went thither, but soon returned, and another place had to be procured for him, at the court of the Duke of Bavaria.

While there, instead of helping to pay his sister's dowry, as he had promised, he married; had an extrava-

gant wedding feast, and then wrote his hard-working brother: "I know that you will say that I should have waited, and thought of our sisters before taking a wife. But, good heavens! the idea of toiling all one's life just to put by a few farthings to give one's sisters! This yoke would be indeed too heavy and bitter; for I am more than certain that in thirty years I should not have saved enough to cover this debt."

With all the pressure upon him for money, Galileo kept steadily on in his absorbing studies. In the year 1609, he constructed a telescope. It is true that Hans Lipperhey, of Germany, had invented a spy-glass, and presented it to Prince Maurice, so that the principle was understood; but nobody gave it practical illustration till Galileo, having heard of the glass, began to reflect how an instrument could be made to bring distant objects near. In a leaden tube, he fixed two glasses, both having one side flat, and the other side of the one concave and the other convex. By this, objects appeared three times nearer and nine times larger. A few days later, he hastened with his leaden tube to Venice, to exhibit it to the Doge and the Senate. He wrote to a friend:—

Many gentlemen and senators, even the oldest, have ascended at various times the highest bell-towers in Venice, to spy out ships at sea, making sail for the mouth of the harbor, and have seen them clearly, though without my telescope they would have been invisible for more than two hours. The effect of this instrument is to show an object at a distance of, say, fifty miles, as if it were but five miles off.

Perceiving of what great utility such an instrument would prove in naval and military operations, and seeing that His Serenity greatly desired to possess it, I resolved four days ago to go to the palace and present it to the Doge as a free gift. And on quitting the presence-chamber, I was com-

manded to bide awhile in the hall of the senate, whereunto, after a little, the Illustrissimo Prioli, who is Procurator and one of the Riformatori of the University, came forth to me from the presence-chamber, and, taking me by the hand, said, "that the senate, knowing the manner in which I had served it for seventeen years at Padua, and being sensible of my courtesy in making it a present of my telescope, had immediately ordered the Illustrious Riformatori to elect me (with my good-will) to the professorship for life, with a stipend of one thousand florins yearly."

This must have been a comfort to the now famous Galileo, as it was, doubtless, to the useless Michelangelo, and the two brothers-in-law! He could now live in comparative peace and rest.

On his return to Padua, he began eagerly to study the heavens. He found that the surface of the moon was mountainous; that the Milky Way was composed of an immense number of small stars and nebulous matter; that Orion, instead of being made up of seven heavenly bodies, had over five hundred stars; and that the Pleiades were not seven, but thirty-six. In January, 1610, he discovered the four moons of Jupiter, and that they revolved around it. July 25 of the same year, he discovered the ring of Saturn; in October, the phases of Venus, and later, the solar spots.

Florence and Padua were in a blaze of excitement. These new discoveries seemed to prove that the earth was not the center of the universe, but that Copernicus was right when he declared the sun to be the center. Great opposition began to develop itself. Some of the Aristotelians declared that the telescope of Galileo showed things which do not exist. "It was ridiculous," they said, "that four planets (Jupiter's moons) were chasing each other around a large planet.

"It is angels who make Saturn, Jupiter, the sun, etc.,

turn round. If the earth revolves, it must also have an angel in the center to set it in motion; but if only devils live there, it would, therefore, be a devil who would impart motion to the earth.

"The planets, the sun, the fixed stars, all belong to one species; namely, that of stars—they, therefore, all move, or all stand still.

"It seems, therefore, to be a grievous wrong to place the earth, which is a sink of impurity, among the heavenly bodies, which are pure and divine things."

Libri, one of the Pisan professors, spoke of the new discoveries as "celestial trifles." When he died, Galileo naïvely remarked, "Libri did not choose to see my celestial trifles while he was on earth; perhaps he will, now he is gone to heaven."

Galileo now longed for freedom from teaching, that he might have his time for study and writing. He had planned, he said, "two books on the system of the universe; an immense work (idea, *concetto*), full of philosophy, astronomy, and geometry: three books on local motion, a science entirely new; no one, either ancient or modern, having discovered any of the marvellous accidents which I demonstrate in natural and violent motions; so that I may, with very great reason, call it a new science, discovered by me from its very first principles: three books on mechanics, two on the demonstration of its first principles, and one of problems; and though this is a subject which has already been treated by various writers, yet all which has been written hitherto neither in quantity nor otherwise is the quarter of what I am writing on it. I have also various treatises on natural subjects, on sound and speech, on sight and colors, on the tide, on the composition of continuous quantity, on the motion of animals, and others; besides, I have also an idea of writing some books on the military art, giving not

only a model of a soldier, but teaching, with very exact rules, all which it is his duty to know that depends on mathematics; as, for instance, the knowledge of encampment, drawing up battalions, fortifications, assaults, planning, surveying, the knowledge of artillery, the use of various instruments, etc."

With all this work in mind, he resigned the professorship at Padua, and removed to Florence, the Grand Duke Cosmo II giving him a yearly salary of about one thousand dollars, and the title of Philosopher to His Highness.

His first thought, as ever, was for his family. He asked an advance of two years' salary, and paid the dowry debts of his sisters' grasping husbands.

In 1611, his expenses paid by the Grand Duke, he went to Rome to show his "celestial novelties," as they were called, to the pope and the cardinals. He was received with great attention, and all seemed delighted to look upon the wonders of the heavens, provided always that nothing could be proved against the supposed assertion of the Bible that the earth did not move!

Galileo soon published his "Discourse on Floating Bodies," which aroused violent opposition; "Spots observed on the Body of the Sun," and the "Discourse on the Tides."

Four years later, he was again in Rome to plead for the Copernican system, and to defend his own conduct in advocating a thing in opposition to the Catholic church. He said: "I am inclined to think that the authority of Holy Scripture is intended to convince men of those truths which are necessary for their salvation, and which, being far above man's understanding, cannot be made credible by any learning, or any other means than revelation by the Holy Spirit. But that the same God, who has endowed us with senses, reason, and understanding,

does not permit us to use them, and desires to acquaint us in any other way with such knowledge as we are in a position to acquire for ourselves by means of those faculties, *that,* it seems to me, I am not bound to believe, especially concerning those sciences about which the Holy Scriptures contain only small fragments and varying conclusions; and this is precisely the case with astronomy, of which there is so little that the planets are not even all enumerated."

However, in spite of Galileo's logic, the church decreed that all books which stated the Copernican system as true should be prohibited; as a mathematical hypothesis, it might be speculated upon. This was a great disappointment to Galileo, who loved and revered the Roman Catholic faith. He went home to the Villa Segni, at Bellosguardo, near Florence, and for seven years led a studious and secluded life.

His greatest comfort, during these quiet years, was the devotion of his daughter, Polissena, who had entered a convent as Sister Maria Celeste. While in Padua, Galileo had three children by Marina Gamba, a Venetian woman of inferior station. She afterwards married a man of her own class, and Galileo took his children to his own home; a condition of things possible with the low moral standard of the time. The two daughters were placed in a convent, while the son, Vincenzo, was educated for the profession of medicine, but he seems to have been a disappointment and a source of discomfort.

Maria Celeste, in the convent of St. Matthew, loving and tender, and helpful to all around her, wrote constantly to the man whom she idolized.

I put by carefully, [she says], the letters you write me daily, and when not engaged with my duties, I read them over and over again. This is the greatest pleasure I have,

and you may think how glad I am to read the letters you receive from persons who, besides being excellent in themselves, have you in esteem.

Again she writes,

I leave you to imagine how pleased I am to read the letters you constantly send me. Only to see how your love for me prompts you to let me know fully what favors you receive from these gentlemen is enough to fill me with joy. Nevertheless I feel it a little hard to hear that you intend leaving home so soon, because I shall have to do without you, and for a long time too, if I am not mistaken. And your lordship may believe that I am speaking the truth when I say that except you there is not a creature who gives me any comfort. But I will not grieve at your departure because of this, for that would be to complain when you had cause for rejoicing. Therefore I too will rejoice, and continue to pray to God to give you grace and health to make a prosperous journey, so that you may return satisfied, and live long and happily, all which, I trust, will come to pass by God's help.

I send two baked pears for these days of vigil. But as the greatest treat of all, I send you a rose, which ought to please you extremely, seeing what a rarity it is at this season. And with the rose, you must accept its thorns, which represent the bitter passion of our Lord, while the green leaves represent the hope we may entertain that through the same Sacred Passion we, having passed through the darkness of this short winter of our mortal life, may attain to the brightness and felicity of an eternal spring in heaven.

Only in one respect does cloister life weigh heavily on me; that is, that it prevents my attending on you personally, which would be my desire, were it permitted. My thoughts are always with you.

And so the seven years of study went by, with the sweet love of Maria Celeste to brighten them. There are none so great that they can live without affection.

At the end of the seven years, Urban VIII came to the pontifical throne, and Galileo and other scientists rejoiced, for he had seemed liberal in thought and generous in heart. When he was cardinal, he had sent a letter to Galileo, saying, "The esteem which I always entertain for yourself and your great merits has given occasion to the enclosed verses. If not worthy of you, they will serve at any rate as a proof of my affection, while I purpose to add lustre to my poetry by your renowned name. Without wasting words, then, in further apologies, which I leave to the confidence which I place in you, I beg you to receive with favor this insignificant proof of my great affection."

At Easter, 1624, Galileo, now sixty years old, resolved to proceed to Rome, to welcome the new pope, and urge his approval of the Copernican theory. Frail in health, he was carried most of the way in a litter. During a visit of six weeks, he had six long audiences with Urban VIII; but, though he was affably received, the pope was in no wise convinced, but rather tried to convince Galileo that he was in error.

Yet so kind was he that Galileo went back to Florence with the hope and belief that he could bring out his great work, "Dialogues on the Two Principal Systems of the World, the Ptolemaic and Copernican," without opposition from the church. In this book, Galileo gave the results of scientific research and discovery in the half century preceding, using such clear yet brilliant style in writing as to make the work attractive even to the unlearned.

It was ready for publication in March, 1630, but to be sure that the pope did not object, Galileo was urged to go in person to Rome. He went and presented the matter to Urban, who gave his consent provided that the title should show that the Copernican system was treated

as a hypothesis merely, and that he, the pope, should write the closing argument.

Rather than forego the publication of that upon which he had worked for years, Galileo consented, and returned to Florence. A license to publish was then obtained from the Inquisitor-General, and the Vicar-General of Florence, after great delay. A second and a third time the papal authorities wished to look over the manuscript. Two years went slowly by.

Other anxieties came to the man of sixty-eight, besides the long delay. The impecunious Michelangelo sent his wife, seven children, and a German nurse, to the home of Galileo, to be taken care of. The eldest nephew was sent to Rome to study music. He was found to be obstinate, impudent, and dissolute, "wicked ways" which his weak and indulgent father said "he did not learn from me, or any one else belonging to him. It must have been the fault of his wet nurse!"

Galileo's son Vincenzo had married and brought his wife home to live. Strange fortune for this man of genius! Strange that he must have helpless relatives, and constant pecuniary troubles. Most great lives are as pathetic as they are great.

As ever, the one gleam of light was the daily letter from Maria Celeste, in which she expressed a tenderness beyond what any daughter ever had for a father. "But I do not know how to express myself, except by saying that I love you better than myself. For, after God, I belong to you; and your kindnesses are so numberless that I feel I could put my life in peril, were it to save you from any trouble, excepting only that I would not offend His Divine Majesty."

Finally Galileo moved to Arcetri, over against the convent, to be near the one who alone satisfied his heart.

In January, 1632, the "Dialogues" appeared. Copies

were sent to his friends and disciples throughout Italy. The whole country applauded, and at last Galileo seemed to have won the homage he had so long deserved.

But a storm was gathering. Enemies were at work prejudicing the mind of Urban VIII, making him feel that Galileo had wrought evil to the church. At once an order came from the Inquisition to secure every copy in the booksellers' shops throughout Italy, and to forward all copies to Rome.

In October of the same year of publication, Galileo was summoned to appear at Rome, to answer to that terror of past centuries, the charge of heresy. His friends urged that he was old and feeble, and that he would die on the journey, but Urban's commands were peremptory.

Galileo was deeply depressed by the summons, and wrote a friend: "This vexes me so much that it makes me curse the time devoted to these studies, in which I strove and hoped to deviate somewhat from the beaten track generally pursued by learned men. I not only repent having given the world a portion of my writings, but feel inclined to suppress those still in hand, and to give them to the flames, and thus satisfy the longing desire of my enemies, to whom my ideas are so inconvenient."

On January 20, 1633, the decrepit old man set out in a litter for Rome, arriving on February 13. On April 12, he was brought before the Inquisition, and briefly examined and then remanded to prison, though treated with great leniency. The anxiety and deprivation from the outdoor exercise brought on illness, and he was confined to his bed till led a second time before the Inquisition, April 30.

Weak, aged, in fear of torture, he made the melancholy confession that his "error had been one of vainglorious ambition, and pure ignorance and inadvertence." Pure ignorance! from the man who had studied for fifty years

all that the world knew of science! But he recalled how men had died at the stake for offending the church. The world is not full of men and women who can suffer death for their convictions, however much we may admire such courage. On May 10, he was summoned a third time before the Inquisition, and told that he had eight days in which to write his defence. In touching language he stated how the book had been examined and re-examined by the authorities, so that there might be nothing heterodox in it; and then he urged them to consider his age and feeble health.

A fourth time he came before the Holy Congregation, June 21, and was asked whether he held that the sun is the center of the solar system, and that the earth is not the center, and that it moves. He replied, "I do not hold, and have not held this opinion of Copernicus since the command was intimated to me that I must abandon it; for the rest, I am here in your hands,—do with me what you please."

And then June 22, in the forenoon, in the large hall of the Dominican Convent of St. Maria sopra la Minerva, in the presence of cardinals and prelates, he heard his sentence.

"The proposition that the sun is the centre of the world and does not move from its place is absurd, and false philosophically, and formally heretical, because it is expressly contrary to the Holy Scripture.

"The proposition that the earth is not the centre of the world and immovable, but that it moves, and also with a diurnal motion, is equally absurd and false philosophically; and theologically considered, at least, erroneous in faith. . . . Invoking, therefore, the most holy name of our Lord Jesus Christ and of His most glorious mother and ever Virgin Mary . . . we say, pronounce, sentence, declare, that you, the said Galileo, by reason of the mat-

ters adduced in process, and by you confessed as above, have rendered yourself, in the judgment of this Holy Office, vehemently suspected of heresy,—namely, of having believed and held the doctrine, which is false and contrary to the sacred and divine Scriptures,—that the sun is the center of the world and does not move from east to west, and that the earth moves and is not the center of the world. . . . We condemn you to the formal prison of this Holy Office during our pleasure, and, by way of salutary penance, we enjoin that for three years to come you repeat once a week the seven Penitential Psalms."

Galileo was also required to "abjure, curse, and detest the aforesaid errors and heresies." And then the white-haired man of seventy, humbly kneeling before the whole assembly, made the pitiful abjuration of his belief. "I abjure with a sincere heart and unfeigned faith, I curse and detest the said errors and heresies, and, generally, all and every error and sect contrary to the Holy Catholic Church."

Pitiful spectacle of intolerance! If we of this nineteenth century have learned to tolerate and treat with respect the beliefs of others though widely divergent from our own, perhaps this wretched drama was not acted in vain.

It has been said that Galileo exclaimed as he rose from his feet, *"E pur si muove,"* "It moves, for all that," but this would have been well-nigh an impossibility, in the midst of men who would instantly have taken him to a dungeon, and the story is no longer believed.

On July 9, poor Galileo was allowed to leave Rome for Siena, where he stayed five months in the house of the archbishop, and then became a prisoner in his own house at Arcetri, with strict injunctions that he was "not to entertain friends, nor allow the assemblage of many at a time."

He wrote sadly to Maria Celeste, "My name is erased from the book of the living." Tender words came back, saying that it seemed "a thousand years" since she had seen him, and that she would recite the seven penitential psalms for him, "to save you the trouble of remembering it."

In less than a year, sweet Maria Celeste had said the last psalms for him. She died April 1, 1634, at thirty-three years of age, leaving Galileo heart-broken; "a woman," he said, "of exquisite mind, singular goodness, and most tenderly attached to me."

He went to work on another book, but he said, pathetically, "I hear her constantly calling me!" Beautiful spirit, that will forever shed a halo around the name of Galileo Galilei!

In the summer of 1636, he completed his "Dialogues on Motion," and sent it to Leyden for publication. The next year he made his last discovery, known as the moon's librations.

The house at Arcetri had become dark and lonely. The wife of Michelangelo, her three daughters and a son, had all died of the plague. It was doubly dark, for Galileo had become hopelessly blind, "so that this heaven, this earth, this universe, which I by my marvellous discoveries and clear demonstrations had enlarged a hundred thousand times beyond the belief of the wise men of bygone ages, henceforward for me is shrunk into such a small space as is filled by my own bodily sensations."

His last work was a short treatise on the secondary light of the moon. "I am obliged now," he said, sadly, "to have recourse to other hands and other pens than mine since my sad loss of sight. This, of course, occasions great loss of time, particularly now that my memory is impaired by advanced age; so that in placing my thoughts on paper, many and many a time I am forced to have

the foregoing sentences read to me before I can tell what ought to follow; else I should repeat the same thing over and over."

He had planned other work, but death came on the evening of January 8, 1642, eight years after Celeste left him. His beloved pupils Torricelli and Viviani, and his son Vincenzo, stood by his bedside.

He desired to be buried in the family vault of the Galilei in Santa Croce, at Florence, and the city at once voted a public funeral and three thousand crowns for a marble mausoleum. But the church at Rome prevented, lest the pernicious doctrine that the earth moves, should thereby have confirmation. He was therefore buried in an obscure corner of Del Noviziato, a side chapel of Santa Croce.

A century later, March 12, 1737, in the presence of the learned men of Italy, with great ceremony, the bones of Galileo were removed to a new resting-place in Santa Croce, and buried with his beloved friend, Viviani. An imposing monument was erected over him. The works of Galileo, in sixteen volumes, are no longer prohibited by the Church, as they were in his lifetime. The truth finally triumphed, as it always does.

SIR ISAAC NEWTON

In the same year, 1642, in which Galileo, sad and blind, went away from the earth, Isaac Newton came to make his home upon it.

He was born December 25, the only child of Isaac Newton and Hannah Ayscough. The father died at thirty-seven, a few months after his marriage, and the young wife, after the birth of her child, was both father and mother to the helpless infant. He was so frail that there seemed little probability that he could live to manhood, or even boyhood. Naturally, between mother and son there grew a most ardent affection, which neither time nor death could change.

The manor-house of Woolsthorpe in Colsterworth, Lincoln county, was a two-story stone building, owned for a century by the Newton family, and bringing a limited income from the little farm in connection with it. Here Isaac passed his childhood, going to the schools near by, and learning to read, write, and cipher.

At twelve, he was sent to the public school at Grantham, where he showed little taste for study, and managed easily to stand at the foot of his class. When he was the last in the lowermost form but one, the boy next above him, as they were going to school, gave Isaac a kick, which occasioned severe pain. Stirred with wrath, Isaac challenged the other boy to a fight. For this purpose, they repaired to a neighboring churchyard, where young Newton, though much the smaller and weaker of the two, pounded his antagonist till he was glad to come to any terms of submission.

He resolved now that this boy should no longer stand above him in scholarship, and with a new ambition and energy born of his insult, he soon rose to the highest place in the school. It was not idleness, probably, that made Newton a poor scholar, but his mind was absorbed with making saws, hammers, hatchets, and other tools.

He made a windmill and placed it on the top of his home, the wind putting it in motion. When there was no wind, a novel expedient was resorted to. A mouse, which was called "the miller," was trained to turn the windmill by walking on a tread wheel, with some corn just beyond his reach! All through life, he was exceedingly kind to animals, and could never tolerate shooting or hunting for sport. He objected to one of his nephews, when praised in his presence, "that he loved killing of birds," and this was sufficient to win his disesteem. It is probable, therefore, that the little mouse was kindly cared for by the young experimenter.

He also made a water clock, about four feet high, with a dial-plate at the top, with figures of the hours. The index was turned by a piece of wood, which either fell or rose by water dropping. Every morning the lad supplied his clock with the proper amount of water.

Besides these, he invented a four-wheeled carriage, which was moved with a handle by the person who sat in it. For his boy friends, he made lanterns of "crimpled paper" with a candle inside, to light them to school in the dark winter mornings, and paper kites of the best form and proportion. In dark nights he tied the lanterns to the tails of his kites, and ignorant people sometimes mistook them for comets!

On the manor-house at Woolsthorpe he carved sundials, which were visible a century later. He was a "sober, silent, and thinking lad," who was always hammering in his room, or making drawings with his pen and

pencil, designing with charcoal on his walls, birds, animals, ships, and mathematical diagrams.

Mrs. Newton, the mother, had married again, after a singular courtship. "Mr. Smith, a neighboring clergyman, who had a very good estate, had lived a bachelor till he was pretty old, and, one of his parishioners advising him to marry, he said he did not know where to meet a good wife. The man answered, 'The widow Newton is an extraordinary good woman.' 'But,' said Mr. Smith, 'how do I know she will have me, and I don't care to ask and be denied; but if you will go and ask her, I will pay you for your day's work.'

"He went accordingly. Her answer was, she would be advised by her brother Ayscough, upon which Mr. Smith sent the same person to Mr. Ayscough on the same errand, who, upon consulting with his sister, treated with Mr. Smith, who gave her son Isaac a parcel of land, one of the terms insisted upon by the widow if she married him."

Though for a time she was thus removed from Isaac, leaving him with his grandmother, on the death of Rev. Mr. Smith, she returned to the manor-house.

When Isaac had reached his fifteenth year, his mother, not seeming to think of any profession for her mechanical son, decided to make of him a farmer and grazier. On Saturdays, the market day at Grantham, she would send him with grain and other agricultural produce, in the care of an old and trusty servant. The boy had no taste for selling produce, and would hasten to the attic in the house of Mr. Clark, an apothecary, with whom he had boarded while at school, and there spend his hours in reading old books, till the time came for him to go home, the servant meantime having sold the vegetables.

Sometimes, however, the lad would not go as far as Grant, but, seating himself beside a hedge along the road,

would read some favorite author till the servant returned. When his mother sent him to watch the cattle, they enjoyed a neighbor's corn-field, while he enjoyed a book or whittled out water-wheels. It did not seem intentional disobedience toward a mother of whom he was very fond, but complete absorption in some other pursuit.

When he was sixteen he was greatly interested in finding the proper form of a body which would offer the least resistance when moving in a fluid. In a severe storm, to test the force of the gale, he jumped first in the direction in which the wind blew, and then in opposition to the wind, and after measuring the length of the leap in both directions, and comparing it with the length to which he could jump in a perfectly calm day, he was enabled to compute the force of the storm.

His mother soon found that her boy would not make a successful farmer, and sent him back to school at Grantham, to prepare for Trinity College, Cambridge, which he entered when he was nineteen.

It is probable that the time spent at Grantham was a happy time; for young Newton there met and; it is said, loved Miss Storey, sister of Dr. Storey, a physician near Colsterworth, and daughter of the apothecary's second wife. She was two or three years younger than Newton, a girl of attractive face and unusual talents. As his income as a Fellow was small, after leaving college, they did not marry, though his interest in her continued unabated through life. Though she was twice married, he never paid a visit to Woolsthorpe without going to see her, and liberally relieved her from little pecuniary embarrassments, when his own circumstances had become easy. How the world loves constancy; an affection which knows no change! That he would have been happier in those quiet years of study, even in his poverty, had he

married, is probable; but that the world gained by his undivided devotion to science, is equally probable.

On July 8, 1661, Newton entered college, and soon, through the study of Descartes' Geometry, showed his skill in higher mathematics. And now began an almost unexampled development of mind.

At twenty-two, he was studying a comet so closely, and the circles and halo round the moon, that he impaired his health by sitting up late at night. In 1665, May 20, when he was twenty-three, he committed to writing his first discovery of fluxions—"the infinitely small increase or decrease of a variable or flowing quantity in a certain infinitely small and constant period of time."

The same year, when the college had been dismissed on account of the plague in Cambridge, Newton made his immortal discovery of the Attraction of Gravitation. While sitting alone in his garden at Woolsthorpe, and observing an apple fall to the ground, it occurred to him that as the same power by which the apple fell was not sensibly diminished at the summits of the loftiest spires, nor on the tops of the highest mountains, it might extend to the moon, about which he had been studying, and retain her in her orbit. If to the moon, why not to the planets?

The tree from which the apple fell was so much decayed in 1820, that it was cut down, but the wood was carefully preserved by Mr. Turnor of Stoke Rocheford.

In the beginning of the following year, 1666, when Newton was twenty-four, he purchased a prism, in order to make some experiments on Descartes' theory of colors. He made a hole in his window shutter, darkened the room, and admitted a ray of the sunlight. On the opposite wall he saw the solar or prismatic spectrum, an elongated image of the sun, about five times as long as it was broad, and

consisting of *seven* different colors; red, orange, yellow, green, blue, indigo, and violet. White light was thus discovered to be of a compound nature; a mixture of all the colors. He said, "Whiteness is the usual color of light; for light is a confused aggregate of rays endued with all sorts of colors, as they are promiscuously darted from the various parts of luminous bodies." If any one color predominates, the light will incline to that color, as the yellow flame of a candle. Heretofore, there had been all sorts of conjectures about the nature and origin of colors. Descartes believed them to be a modification of light, depending on the direct or rotary motion of its particles. But Newton showed by many experiments that color is a property of light, or innate in light itself. We speak of a thing as red because it reflects red, and absorbs all the other colors. The green leaf stops or absorbs the red, blue, violet rays of the white light, and reflects and transmits only those which compose its green.

He also found that the red rays are refracted or turned out of their course least of all the colors, and violet most, thereby discovering the different refrangibility of the rays of light; "a discovery which has had the most extensive applications to every branch of science, and, what is very rare in the history of inventions, one to which no other person has made the slightest claim."

His beautiful experiments with rings resulted in his Scale of Colors, of great value in optical research.

In 1668, when Newton was twenty-six, he constructed a small reflecting telescope, and soon a larger one, which he sent to the Royal Society; and was made a member of that body in 1671. Two years previously he had been appointed to the Lucasian professorship of mathematics at Cambridge.

He was now, at twenty-seven, spoken of as a man of "unparalleled genius." He had discovered the compound

nature of white light, the attraction of gravity, fluxions, and made the first reflecting telescope ever directed toward the heavens, though one had been invented previously, by James Gregory, of Aberdeen. The boy who had thought of a mouse to turn his windmill had thought out some of the sublimest things in nature, and was henceforward to rank as one of the few master-minds of science. Newton's doctrine of colors met with the most bitter opposition. At last, he became so tired of the controversy, that he wrote Leibnitz, "I was so persecuted with discussions arising out of my theory of light, that I blamed my own imprudence for parting with so substantial a blessing as my quiet to run after a shadow." To another he wrote, "I see I have made myself a slave to philosophy; but if I get free of Mr. Linus's business, I will resolutely bid adieu to it eternally, excepting what I do for my private satisfaction, or leave to come out after me; for I see a man must either resolve to put out nothing new, or to become a slave to defend it."

Newton was also troubled pecuniarily at this time, and asked to be excused from the weekly payments to the Royal Society, thereby resigning his membership. He even meditated the study of law, as his income was so limited. Strange that so many of the great things of this life are wrought out by those who are in sorrow or privation.

But amid all the opposition to his discoveries and his poverty, the unparalleled devotion to study was continued. When he was weary of other branches, he said "he refreshed himself with history and chronology." Years afterward he published the "Chronology of Ancient Kingdoms amended, to which is prefixed a short chronicle, from the first memory of things in Europe, to the Conquest of Persia, by Alexander the Great." Says a gentleman who was with him for years, "I never knew him to

take any recreation or pastime, either in riding out to take the air, walking, boating, or any other exercise whatever, thinking all hours lost that were not spent in his studies, to which he kept so close that he seldom left his chamber except at term time, when he read in the schools, as being Lucasianus Professor, where so few went to hear him, and fewer that understood him, that oftentimes he did in a manner, for want of hearers, read to the walls. . . .

"So intent, so serious upon his studies that he ate very sparingly, nay, ofttimes he has forgot to eat at all, so that, going into his chamber, I have found his mess untouched, of which when I have reminded him he would reply, 'Have I?' and then making to the table, would eat a bit or two standing, for I cannot say I ever saw him sit at table by himself. At some seldom entertainments the masters of colleges were chiefly his guests.

"He very rarely went to bed till two or three of the clock, sometimes not till five or six, lying about four or five hours, especially at spring and fall of the leaf, at which times he used to employ about six weeks in his laboratory, the fire scarcely going out either night or day, he sitting up one night, and I another, till he had finished his chemical experiments, in the performances of which he was the most accurate, strict, exact. . . ."

When his most intense studies were carried on, "he learned to go to bed at twelve, finding by experience that if he exceeded that hour but a little, it did him more harm in his health than a whole day's study."

"He rarely went to dine in the hall, except on some public days, and then if he has not been minded, would go very carelessly, with shoes down at heels, stockings untied, surplice on, and his head scarcely combed. . . . At some seldom times when he designed to dine in the hall, he would turn to the left hand and go out into the

street, when making a stop when he found his mistake, would hastily turn back, and then sometimes, instead of going into the hall, would return to his chamber again. . . . In his chamber he walked so very much that you might have thought him to be educated at Athens, among the Aristotelian sect."

So absent-minded was he, the story is told of him, that going home to Colsterworth, he led his horse up a hill. When he decided to remount, the animal had slipped the bridle and gone away unperceived, though Newton held the bridle in his hand all the time. He would often sit down on his bedside after he rose, and remain there for hours without dressing, so completely absorbed was he in his thought. How few in all this world have been so devoted to science! And yet how many expect success without this devotion!

The same gentleman writes of Newton, "His carriage was very meek, sedate, and humble, never seemingly angry, of profound thought, his countenance mild, pleasant, and comely. I cannot say I ever saw him laugh but once."

In 1687, when Newton was forty-five, his *Philosophiæ Naturalis Principia Mathematica* was published. "The *Principia* consists of three books. The First Book, besides the definition and axioms, or laws of motion, with which it begins, consists of fourteen sections, in the first of which the author explains the method of prime and ultimate ratios used in his investigations, and which is similar to the method of fluxions. The other sections treat of centripetal forces, and motions in fixed and movable orbits.

"The Second Book consists of nine sections, and treats of bodies moving in resisting media, or oscillating as pendulums.

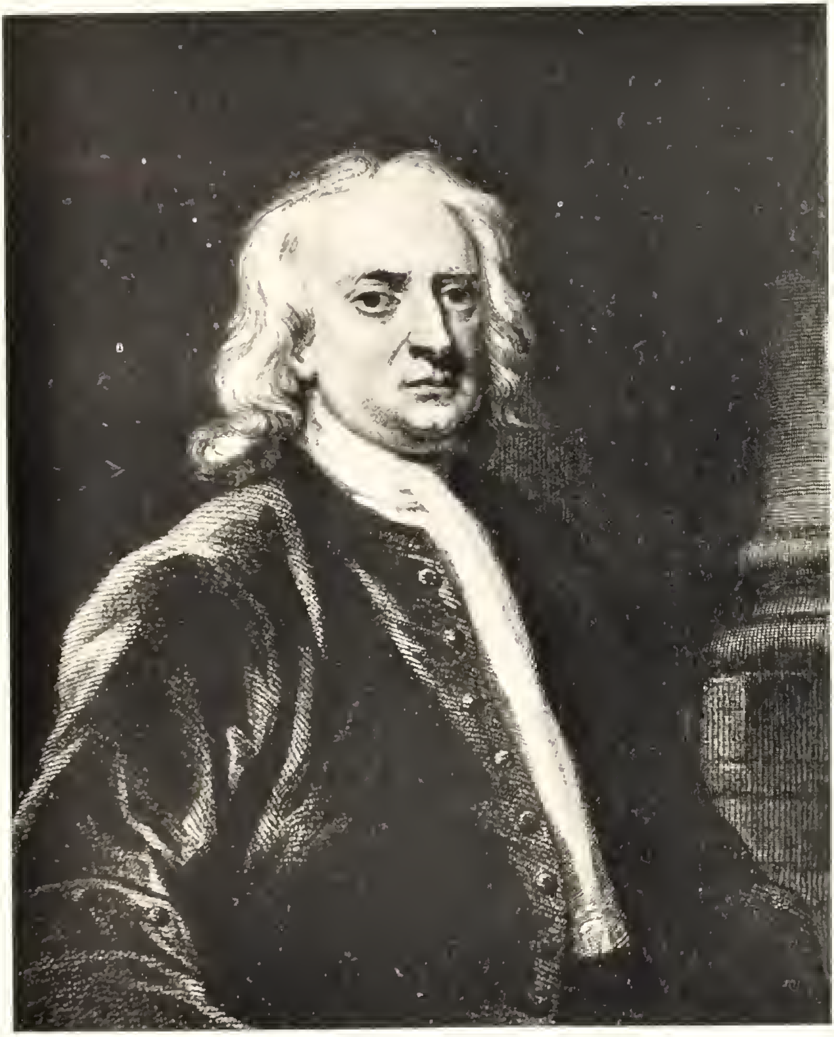
"The Third Book consists of five sections, on the

Causes of the System of the World, on the Quantity of Lunar errors, on the Quantity of the Tides, on the Precession of the Equinoxes and on Comets."

The great principle of the *Principia* is universal gravitation, "That every particle of matter in the universe is attracted by or gravitates to every other particle of matter, with a force inversely proportional to the squares of their distances." By the laws of gravity, Newton was enabled to calculate the quantity of matter in the sun, and in all the planets, and even to determine their density, results which Adam Smith said "were above the reach of human reason and experience." He ascertained that the weight of the same body would be twenty-three times greater at the surface of the sun than at the surface of the earth, and that the density of the earth was four times greater than that of the sun. He found the true figure of the earth; he explained the phenomena of the tides.

Of the "Principia," Sir David Brewster says, in his able life of Sir Isaac Newton, it is "a work which will be memorable not only to the annals of one science or of one country, but which will form an epoch in the history of the world, and will ever be regarded as the brightest page in the records of human reason,—a work, may we not add, which would be read with delight in every planet of our system,—in every system of the universe. What a glorious privilege was it to have been the author of the 'Principia'!

"There was but one earth upon whose form, and tides, and movements, the philosopher could exercise his genius, —one moon whose perturbations and inequalities and actions he could study,—one sun whose controlling force and apparent motions he could calculate and determine,— one system of planets whose mutual disturbances could tax his highest reason,—one system of comets whose eccentric paths he could explore and rectify,—and one uni-



SIR ISAAC NEWTON

From the portrait by Vanderbank, in the Royal Society

verse of stars to whose binary and multiple combinations he could extend the law of terrestrial gravity.

"To have been the chosen sage summoned to the study of that earth, these systems, and that universe, the favored lawgiver to worlds unnumbered, the high priest in the temple of boundless space,—was a privilege that could be granted but one member of the human family;—and to have executed the last was an achievement which, in its magnitude, can be measured only by the infinite in space, and in the duration of its triumphs by the infinite in time. That sage,—that lawgiver,—that high priest was Newton."

The "Principia" created the greatest interest throughout Europe, but met with violent opposition. While Laplace said it would take "pre-eminence above all the other productions of human genius," the majority could not believe that great planets were suspended in empty space, and retained in their orbits by an invisible power in the sun.

When Newton presented copies to the heads of colleges, some of them, Dr. Babington of Trinity among the number, said, "they might study seven years before they understood anything of it."

In 1687, Newton's method of fluxions was first published, twenty years after its invention, and then because the friends of Leibnitz, the author of the "Differential Calculus," claimed priority of discovery. The quarrel aroused the scientific world, embittered the silent mathematician, and impaired his health.

In 1689, when he was forty-seven, he was chosen member of parliament, and represented Cambridge University in the House of Commons for thirteen months. He took no active part in the debates, but was of course respected for his wonderful mind.

This same year, his beloved mother died. Anxiously

he had watched through whole nights by her bedside, seeking in all ways to keep her from leaving him alone in the world.

He was now nearly fifty. His life had been laborious, with an insufficient income. His friends, John Locke among the number, tried to obtain various positions for him, but failed. They recommended him for provost of Kings College, but the position could not be obtained because he had not taken priest's orders.

Seemingly unappreciated, worn with his incessant brain work, his appetite failing, and unable to sleep, with neither mother nor wife to comfort him, the sensitive organization of the great man became overstrained, and mind and body were unfitted for work. It is stated that his ill health was in part consequent upon the burning of some manuscripts on optics, by a lighted candle on the table among his papers.

When he was fifty-three, the long hard road of poverty turned into a highway of plenty, through the influence of a friend. Charles Montague, an associate of Newton at the university and also in parliament, though nineteen years his junior,—intellectual affinities are uninfluenced by age,—had been made Commissioner of the Treasury, then Privy Councillor, then Chancellor of the Exchequer, and later still, Baron of Halifax.

Lord Halifax appointed Newton to be Warden of the Mint, and then Master, with an income of between six thousand and seven thousand five hundred dollars annually, which position he held for the remainder of his life. His home in London, where he kept six servants, with his brilliant niece, Miss Catherine Barton, for his companion, became a place of rest and comfort to the tired philosopher. Lord Halifax was a great admirer of Newton's niece, Miss Catherine Barton, to whom he left, at his death, a beautiful home and twenty-five thousand

dollars, "as a token of the sincere love, affection, and esteem I have long had for her person, and as a small recompense for the pleasure and happiness I have had in her conversation."

The days of privation were over, and Newton had earned this rest and prosperity. Great people often came to dine with him. At one of his dinners, Newton proposed to drink, not to the health of kings and princes, but to all honest persons, to whatever country they belonged. "We are all friends," he added, "because we unanimously aim at the only object worthy of man, which is the knowledge of truth. We are also of the same religion, because, leading a simple life, we conform ourselves to what is right, and we endeavor sincerely to give to the Supreme Being that worship which, according to our feeble lights, we are persuaded will please him most."

Other honors now came to Newton. In 1703, he was elected President of the Royal Society, and was annually re-elected during the remaining twenty-five years of his life. On April 16, 1705, when he was sixty-three, Queen Anne conferred the honor of knighthood upon her most illustrious subject, Sir Isaac Newton, before a distinguished company at Cambridge University. In 1704, the year previous, his great work on optics had been published, written over twenty years before.

About this time, it seems that the great philosopher would have liked to marry Lady Norris, the widow of Sir William Norris, Baronet of Speke, and Member of Parliament. Sent to Delhi as ambassador to the Great Mogul, he died in 1702, between Mauritius and St. Helena, on his homeward passage. He was the third husband to Lady Norris, and Sir Isaac, now over sixty, desired to be the fourth, as appears from the following letter:—

Madam,—Your ladyship's great grief at the loss of Sir William shows that if he had returned safe home, your ladyship could have been glad to have lived still with a husband, and therefore your aversion at present from marrying again can proceed from nothing else than the memory of him whom you have lost. To be always thinking on the dead, is to live a melancholy life among sepulchres, and how much grief is an enemy to your health, is very manifest by the sickness it brought when you received the first news of your widowhood. And can your ladyship resolve to spend the rest of your days in grief and sickness?

Can you resolve to wear a widow's habit perpetually,—a habit which is less acceptable to company, a habit which will be always putting you in mind of your lost husband, and thereby promote your grief and indisposition till you leave it off? The proper remedy for all these mischiefs is a new husband, and whether your ladyship should admit of a proper remedy for such maladies, is a question which I hope will not need much time to consider of.

Whether your ladyship should go constantly in the melancholy dress of a widow, or flourish once more among the ladies; whether you should spend the rest of your days cheerfully or in sadness, in health or in sickness, are questions which need not much consideration to decide them. Besides that your ladyship will be better able to live according to your quality by the assistance of a husband than upon your own estate alone; and, therefore, since your ladyship likes the person proposed, I doubt not but in a little time to have notice of your ladyship's inclinations to marry, at least, that you will give him leave to discourse with you about it.

I am, madam, your ladyship's most humble and most obedient servant.

If Lady Norris "liked the person proposed," as Sir Isaac imagined, a marriage was not the result. It is just possible that he was like Leibnitz, who proposed to a lady when he was fifty. The lady asked for time to take the matter into consideration, and as Leibnitz thus obtained

leisure to consider the matter again, he was never married.

For thirteen years Sir Isaac lived on Jermyn Street, London; then moved to Chelsea, a place dear to those who love George Eliot or admire Carlyle; and then to Martin Street, near Leicester Fields.

In his latter years he wrote much on theological subjects, especially to prove the existence of a Deity. When he was eighty-three he published a third edition of the "Principia." At eighty-five he read manuscript without spectacles. He reasoned as acutely as ever, his memory alone failing.

On March 2, 1727, he presided at a meeting of the Royal Society. He was taken ill on the following day, and, although a great sufferer for several days, never uttered a complaint. He died on Monday, March, 20, and his body was laid in the Jerusalem Chamber, and thence conveyed to Westminster Abbey for burial. The pall was supported by the Lord High Chancellor and several Dukes and Earls.

On the front of his monument are sculptured youths, bearing in their hands emblematic designs of Newton's principal discoveries. One carries a prism, another a reflecting telescope, a third is weighing the sun and planets with a steelyard, a fourth is employed about a furnace, and two others are loaded with money newly coined. The monument bears this inscription.

Here Lies

SIR ISAAC NEWTON, KNIGHT,

Who by a vigor of mind, almost supernatural,
First demonstrated
The motions and figures of the Planets,
The Paths of the Comets, and the
Tides of the Ocean.

He diligently investigated
The different refrangibilities of the Rays of Light,
And the properties of the Colors to which
they give rise.
An Assiduous, Sagacious, and Faithful Interpreter
of Nature, Antiquity, and the Holy Scriptures,
He asserted in his Philosophy the Majesty of
God, and exhibited in his Conduct the
simplicity of the Gospel.
Let Mortals rejoice that there has existed
such and so great
AN ORNAMENT OF THE HUMAN RACE.
Born 25 Dec., 1642; Died 20 March, 1727.

A beautiful full-length, white marble statue of Sir Isaac was erected in the ante-chapel of Trinity College, where he had done his wonderful work, when scarcely more than a boy.

While he gave generously during his life, he said, "they who give nothing till they die, never give at all,"—he left a personal estate of one hundred and sixty thousand dollars, to be divided among his nephews and nieces.

The world honored him at last, and has through all the years. Bishop Burnet said, "Newton had the *whitest* soul he ever knew." His habits were of the best. When asked to take snuff or tobacco, he declined, saying, "he would make no necessities to himself."

He was modest to the last, saying, "that whatever service he had done the public was not owing to any extraordinary sagacity, but solely to industry and patient thought." He said, a short time before his death: "I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

CARL LINNÆUS

In the Swedish town of Upsala sleeps the man who, more than any other, has immortalized Upsala University, and helped to make Sweden an intellectual and studious country. Near by is the monument of dark porphyry, with the plain, shaven face in bronze, wreathed with laurel, and the words *"Carolo a Linné Botanicorum Principi Amici et Discipuli,* 1798."

Nearby is the Botanic Garden, which Linnæus so loved and developed, and the two-and-a-half-story stuccoed house where the great naturalist lived and entertained princes. Under these dark poplars, enormous in size, he taught the pupils who came from all parts of the world to hear him. The dark, closed blinds are as he left them, for Sweden would not change one thing about the precious home. Too little in our own country do we treasure the homes of those who give honor to the nation.

The history of Linnæus is, indeed, a romance. Few have had such great struggles with poverty; few have come off such conquerors. Few lives have given to the world such lessons of cheerfulness, of perseverance, and of untiring industry. He was born, May, 1707, at Rashult, in the south of Sweden, the son of a poor minister, and the eldest of five children. The father, Nils Linnæus, had obtained his education by the hardest toil, and, while he had only poverty to offer his family, he gave them what money could not buy, tender affection, and the inspiring influence of a cultivated mind that loved nature and studied her closely. His mother, Christina, a woman of sense, prudence, and good judgment, was his

idol. He wrote of her in later years: "She possessed all the virtues of her sex, devoting the utmost attention to impressing on my mind the love of virtue, both in precept and example."

From a child he was fond of his father's garden, and gathered from the fields all kinds of wild flowers. He says of himself in his autobiography: "He was scarcely four years old when he accompanied his father at a feast at Mökler, and in the evening, it being a very pleasant season of the year, the guests seated themselves on some flowery turf, listening to the pastor, who made various remarks on the names and properties of the plants, showing them the roots of the succisa, tormentilla, orchids, etc. The child paid the most uninterrupted attention to all he saw and heard, and from that hour never ceased harassing his father about the name, qualities, and nature of every plant he met with; indeed, he very often asked more than his father was able to answer, but, like other children, he used immediately to forget what he had learned, and especially the *names* of plants. Hence the father was sometimes put out of humor, and refused to answer him unless he would promise to remember what was told him. Nor had this harshness any bad effect, for he afterward retained with ease whatever he heard."

When he was eight, a piece of ground was assigned him, which was called "Carl's Garden." Here he gathered plants and flowers, and introduced so many rare weeds that his father had great trouble in eradicating them! So interested did Carl become, that he had nests of wild bees and wasps, not agreeable playthings usually.

But the play days with weeds and wasps came to an end, for the bright boy had to go to school. His first teacher was "a passionate and morose man, better calculated for extinguishing a youth's talents than for improving them," and the next "pursued the same methods,

CARL LINNÆUS

preferring stripes and punishments to encouragements and admonitions." There was little time now for the precious study of flowers. At seventeen he had to go to a gymnasium or high school, where he would be taught classics, and made ready for the ministry, like his father. He had no fondness for the languages, neither for theology or metaphysics: but having obtained two books on botany, he read them day and night, committing them to memory. The teachers and scholars called him "the little botanist."

What was his father's chagrin, when he came to the school to visit him, to hear that Carl was quite unfit for the ministry, but would probably make a good tailor or shoemaker! Poor as he was, he had kept his boy at school for about twelve years. Now, well-nigh disheartened, he stopped, on his way home, to confer with his family physician, Dr. Rothmann. That good man suggested that the boy might like medicine, and accomplish great things in natural history. He offered to take him into his own home, and give him lessons in physiology, which kind proposal the father accepted, though with little faith. The doctor also taught him botany, and Carl grew happy under the new *régime*.

The next year he was sent to the University of Lund, with the following not very creditable certificate from the head master of the gymnasium: "Youth at school may be compared to shrubs in a garden, which will sometimes, though rarely, elude all the care of the gardener, but if transplanted into a different soil, may become fruitful trees. With this view, therefore, and no other, the bearer is sent to the University, where it is possible that he may meet with a climate propitious to his progress." Through a friend, entrance was obtained without showing the obnoxious certificate.

Carl took lodgings at the house of Dr. Stobæus, physi-

cian to the king, who gave him access to his minerals, shells, and dried plants. Delighted at this, the youth at once began to make a collection of his own, and glue them on paper. He longed to gain access to Dr. Stobæus's library, but how should it be accomplished? Finally a young German student, to whom he taught physiology, surreptitiously gained the books needed, and young Linnæus spent nearly the whole nights in reading. The doctor's aged mother did not understand why their lodger kept his light burning into the small hours, and besought her son to investigate. He did so, and found the crestfallen Carl reading his own library books. He forgave the student, took him to his own table and treated him as a son.

Advised by Dr. Rothmann to go to Upsala for better medical opportunities, he proceeded thither, and here began his bitterest poverty. His father could give him only forty dollars. As he was unknown, and without influence, he could obtain no private pupils. Starvation actually stared him in the face. He says, "he was obliged to trust to chance for a meal, and in the article of dress, was reduced to such shifts that he was obliged, when his shoes required mending, to patch them with folded paper, instead of sending them to the cobbler." Often hungry and half clothed, there seemed nothing before the poor Swedish lad but obscurity and early death.

One day in autumn, as he was examining some plants in the Academical Garden, a venerable clergyman, Dr. Olaf Celsius, saw him, and asked him where he came from, how long he had been at the college, and what he knew about plants. He, too, was interested in botany, and was preparing a work on the plants mentioned in the Bible. Perhaps something in Carl's face or manner touched the minister's heart, for he asked him to go home

with him, and soon offered him board in his own house, and gave him access to his valuable library.

The tide of adversity was beginning to turn. Some pupils were obtained, and a little money flowed into the empty pockets. At twenty-two, by a close examination of the stamens and pistils of flowers, he decided upon a new method of arrangement by the sexes of plants, which, in after years, became the basis of his great fame. This procured him the appointment of Assistant Lecturer to Dr. Rudbeck in the Botanical Garden, where, but a year before, he had asked to be the gardener!

He now had a little money, and, what was equally useful, some leisure time. He began his great works, which were not completed for seven years, "Bibliotheca Botanica," "Classes Plantarum," "Critica Botanica," and "Genera Plantarum," "letting," as he said, "not a minute pass unoccupied during his residence at Upsala. For the latter work he examined the characters of eight thousand flowers."

Scarcely had he begun this valuable labor, when the envy of one of the professors became as hard to bear as his previous poverty, and, through friends, he obtained an appointment to study the natural history of Lapland. It was a hazardous expedition for a young man of twenty-five. Now he climbed steep rocks, "which," he says, "broke loose from a spot which my late guide had just passed, and fell exactly where I had been, with such force that it struck fire as it went." Once, when floating down a river, the raft parted in the middle, and he narrowly escaped drowning. "All my food," he says, "in those fatiguing excursions, consisted, for the most part, of fish and reindeer's milk. Bread, salt, and what is found everywhere else, did but seldom recreate my palate." He travelled nearly four thousand miles, mostly on foot,

often through bogs and marshes, with the water to his knees, yet always cheerful, always enthusiastic. On presenting his report to the University, on his return home, they gave him about fifty dollars for his travelling expenses for five months!

A single incident shows the tender heart of the young explorer. Very few birds were visible except the ptarmigan. He says: "The little Alpine variety of the ptarmigan was now accompanied by its young. I caught one of these, upon which the hen ran so close to me that I could easily have taken her also. She kept continually jumping round and round me, but I thought it a pity to deprive the tender brood of their mother; neither would my compassion for the mother allow me long to detain her offspring, which I returned to her in safety." Tenderness to animals seems to be a striking characteristic of great men and women.

During the journey, he found a modest little flower in the great northern forests, in the moss, and this he named *Linnæa borealis,* thinking it was so like himself, expanding in obscurity. He chose for his motto, *Tantus amor florum,* "So great is the love for flowers."

On his return to Upsala, he began courses of private lectures in medicine, but so bitter was the envy of the before-mentioned professor that the archbishop was prevailed upon to prohibit private lectures. Thus deprived of a livelihood, Linnæus turned his attention to mineralogy, visiting the Swedish mines. The Governor of Dalecarlia was so pleased with him that he engaged him to investigate the productions of his country. Here he fell in love with the daughter of John Moræus, a well-to-do physician.

Sara Elizabeth reciprocated the affections of the young man, who was told by the father that he must wait three years for a final answer; for, in truth, Linnæus's financial

prospects were not bright. The University of Upsala did not want him, and there seemed to be no hope of writing or publishing his books on botany. But a man usually achieves little, who does not fight his way at every step. Now, indeed, for love's sake he must make his mark.

After saving about seventy-five dollars, he decided to go to Germany, and take his doctor's degree; but first he must visit his home, out of which his beloved mother had gone at forty-five. "Alas! alas, my mother!" was all he could say, as the tears fell fast upon her grave. She had witnessed his poverty and his heroism; she was not to witness his great renown.

At Hamburg he spent a month, receiving civilities from many scientific men. He showed his good sense in feeling in no wise humiliated because he was poor, a valuable lesson for poor young men and women to learn. At Leyden, good fortune came to him. Dr. Gronovius was so pleased with the manuscript of his "Systema Naturæ" that he requested to publish it at his own expense. By his advice, Carl waited upon the celebrated physician, Boerhaave, and after eight days gained admittance. So famous was this man that when the Emperor of China sent a letter to "Boerhaave, the famous physician in Europe," it easily reached him. He advised a rich banker, Mr. Clifford, to have Linnæus describe his magnificent collection of plants, and to send him to England and elsewhere, to collect specimens for him. This was indeed a blessing. "Here in England," he says, "I lived like a prince, and had one of the finest gardens of the world under my inspection." A society in Amsterdam advanced the money to pay for the plates for his "Flora Lapponica," and fame seemed really to be coming at last.

In his visit to England, Sir Hans Sloane, who founded the British Museum, looked upon him coldly because he had suggested a different system in natural history from

his own! At Oxford, Dillenius said to friends, sarcastically: "See, this is the young man who confounds all botany!" Linnæus felt hurt, and, when about to take his departure from the city, asked the scientist why he had treated him thus. After the young student had explained his work, Dillenius became his warm friend, and pressed him to stay, and even to share his salary with him. Linnæus was greatly pleased with London, and when he saw the golden furze in its green leaves, fell on his knees before it.

On his return to Germany he went to the deathbed of Boerhaave, whose parting words were: "I have lived out my time and done what I could. May God preserve thee, from whom the world expects much more! Farewell, my dear Linnæus!"

He now hastened to the idol of his heart in Sweden, and what was his amazement to find that the friend to whom he had intrusted his correspondence with Sara Elizabeth had been trying to win her for himself! Perhaps it would have been quite as well for Linnæus had he succeeded! However, matters were amicably adjusted, and the long waiting lovers became engaged.

He repaired at once to Stockholm to begin the practice of medicine, still keeping as near Upsala University as possible. And here troubles began anew. He says: "Being unknown to everybody, people were unwilling to trust their lives in my hands. Nay, they even hesitated to trust me with their dogs! Abroad, I had been honored in every place as Princeps Botanicorum; but in my own country I was looked upon as a *Klim,* newly arrived from the subterranean regions! No one cared how many sleepless nights and toilsome hours I passed. Had I not been in love I would certainly have left Sweden and gone abroad."

After a time a fortunate cure effected by him brought

him speedy popularity. "No invalid could now recover without my assistance. I was busy from four in the morning till late in the evening; nor were my nights left undisturbed." He was soon chosen a member of the Upsala Academy, and at the request of the king, through his tutor, Count Tessin, gave public lectures on botany and mineralogy.

And now the rising botanist desired to claim his bride. They were accordingly married June 26, 1739, when Linnæus was thirty-two. Dr. Moræus had waited long enough to see that his daughter was making no mistake. Life now flowed on smoothly. If the "little wife," as he called her, governed him with no very gentle sway in after years, she had great influence over him, and it is said that at her instigation he persecuted his only son. All the more is Linnæus to be admired for accomplishing such a grand work with domestic hindrances. It takes a very great man to be great when his home is not a help to him! However, he always regarded her as "one of the choicest gifts bestowed upon him."

His medical practice brought him plenty of money, but he wrote to a friend: "Once I had plants and no money: now what is money good for without plants?" Soon the desire of his heart was granted, and he was made Professor of Botany at Upsala University, also superintendent of the Botanical Garden.

Now he says: "I render thanks to the Almighty, who has ordered my lot so that I live at this day; and live, too, happier than the King of Persia. I think myself thus blessed because in this academic garden I am principal. This is my Rhodus, or, rather, my Elysium; here I enjoy the spoils of the East and the West, and, if I mistake not, that which far excels in beauty the garments of the Babylonians and the porcelain of China."

His fame grew rapidly. He published, in 1745, his

"Flora Suecica," and a year later his "Fauna Suecica," a description of Swedish plants and animals. His lectures soon, by their enthusiasm and eloquence, brought listeners from all parts of Europe. The number of students in the university grew from five hundred to fifteen hundred, young men coming even from America to hear the great botanist. During the summer he made excursions twice a week, often at the head of two hundred students, and when some rare plant was discovered, the news was announced to the others by horn or trumpet. His scholars, imbued with his spirit, went over the world in scientific investigation. Some died in the Arabian deserts; some in the swamps of Africa. From foreign students he would take no fee, as he desired to show them how he loved his work. Once he said to a German student: "Tell me, candidly, are you rich, and can you afford it? If you can, then give the money to my wife; but, if you be poor, so help me Heaven, I will not take a single farthing from you!"

Most of the scientific societies of Europe made him a member after his great works were published. The Imperial Academy called him "Dioscorides Secundus"; a gold medal was struck in his honor in 1746, and the king made him dean of the College of Physicians. He published two valuable medical books, and received the honor of the Knight of the Polar Star, never before conferred for literary merit. He was made a noble, and took for his motto, *Famam extendere factis,* adorning his crest with the little flower which he discovered in his poverty. He was made rector of the university, holding the position for several years. How different from the time when he could obtain only a chance meal, and covered up the holes in his torn shoes!

He bought two estates, living at one of them—Hammerby—for fifteen years. In 1774, when he was sixty-

seven, he suffered an attack of apoplexy in the Botanical Garden, and, two years later, another stroke made him a paralytic. When he could no longer walk, he used to be carried to his museum, and look long and earnestly at his treasures, gathered from every clime. His memory so failed him that he mixed the Greek and Latin letters, and forgot even his own name. On the 10th of January, 1778, death came to him in his sleep.

The university went into mourning, the king made a public address, and the whole nation regarded it as an irreparable loss. His herbarium and library were sold, after a time, by his wife, to Sir James E. Smith, the founder of the Linnæan Society, of London, where these treasures are now to be seen, and most of the one hundred and eighty works which he published during forty-five years. It is said that the King of Sweden, on learning that the work of Linnæus was going out of the country, sent a man-of-war to recover it, but without avail.

Linnæus was small in body, with large head, and the bright, piercing eyes which usually characterize men and women of genius.

Of his six children, the oldest soon became professor of botany, to assist, and then succeed, his father, but he lacked the parent's just and honorable love of fame. The eldest daughter inherited much of his ability, being the first to discover the luminous property of the nasturtium flowers at night. Sara Elizabeth survived her noble husband many years, and now lies beside him in the cathedral.

SIR WILLIAM HERSCHEL

In Hanover, Germany, in the year 1732, Isaac Herschel and a plain, industrious girl, Anna Ilse Moritzen, began their home life together. The young man did not like the calling of his father, the cultivating of the royal gardens, and learned to play the oboe in the royal band.

He became skilled in music, and, as, one after another, ten children were born into the little home, he taught them to play on the violin and oboe, and such other branches of knowledge as he possessed. After a time his health became impaired with exposure in the Seven Years' War, and then he earned his living by lessons in music, given to scholars at his home.

The children attended the garrison school in Hanover, and learned the ordinary rudiments, besides French and German. Though the father sometimes copied music half the night to eke out his scanty living, he spared no pains to teach them all he could of his favorite art.

The fourth son, William, born November 15, 1738, not only learned French and English rapidly, but studied Latin and arithmetic with the teacher, after hours. He became passionately fond of books, reading their own little store with avidity. The mother, who could not even write, viewed with alarm this intellectual development, feeling that her children, if they became learned, would go away from home—possibly from Germany. Poor, ignorant heart! She cooked and sewed, and prevented her daughters from learning French or drawing; but her weak hand could not stay the power of a mind like William's, bent on acquiring knowledge.

Caroline, the eighth child, born in 1750, twelve years younger than William, looked upon this brother as a marvel; and shy, plain, and silent herself, watched the boy with pride, who, perchance, would be somebody by and by. Alexander, a little older than Caroline, was skilled on the violoncello, and both the boys became members of the Hanover foot guards.

Years later, Caroline gave this picture of that early life: "My brothers were often introduced as solo performers and assistants in the orchestra of the court, and I remember that I was frequently prevented from going to sleep by the lively criticism on music, on coming from a concert; or by conversations on philosophical subjects, which lasted frequently till morning, in which my father was a lively partaker and assistant of my brother William, by contriving self-made instruments. . . .

"Often I would keep myself awake that I might listen to their animating remarks, for it made *me so happy* to see *them so happy*. But generally their conversation would branch out on philosophical subjects, when my brother William and my father often argued with such warmth that my mother's interference became necessary; when the names Leibnitz, Newton, and Euler sounded rather too loud for the repose of her little ones, who ought to be in school by seven in the morning. But it seems that on the brothers retiring to their own room, where they shared the same bed, my brother William had still a great deal to say; and frequently it happened that when he stopped for an assent or reply, he found his hearer was gone to sleep, and I suppose it was not till then that he bethought himself to do the same.

"The recollection of these happy scenes confirms me in the belief, that had my brother William not then been interrupted in his philosophical pursuits, we should have had much earlier proofs of his inventive genius. My fa-

ther was a great admirer of astronomy, and had some knowledge of that science; for I remember his taking me, on a clear frosty night, into the street, to make me acquainted with several of the most beautiful constellations, after we had been gazing at a comet which was then visible. And I well remember with what delight he used to assist my brother William in his various contrivances in the pursuit of his philosophical studies, among which was a neatly turned four-inch globe, upon which the equator and ecliptic were engraved by my brother."

When William was seventeen, the guards went to England for a year, and on their return home he brought one precious memento of the country, Locke "On the Human Understanding." Such a boy would not remain in the foot guards forever. He was delicate in health, so that his parents removed him from the army.

At nineteen, he determined to try his fortune in England. He said good-by to the culture-loving and warm-hearted father, to the poor mother who knew "no other wants than good linen and clothing," and started out to make his way in the world. For three years nothing is known of him, save that he passed through many hardships. He played in military bands whenever and wherever he could find a situation, or at concerts, and led probably a cramped and obscure life.

There was little prospect then that he would become, as Prof. Edward S. Holden says in his admirable life, "the greatest of practical astronomers, and one of the world's most profound philosophers." What the poor German youth thought and felt in those years of trial, we do not know. He had one resource in his loneliness, the reading of useful books.

After about three years, a fortuitous circumstance occurred. It proved "fortuitous" only because young Herschel had studied music faithfully, and had made him-

self ready to fill a fine position, if, poor and without influence, such a position could be obtained.

He obtained a church organ at Halifax, and, one year later, the organ at the Octagon Chapel in Bath, a fashionable city of England. This was another and higher step on the road to fame. He now gave nearly forty lessons a week to pupils. He composed music, and wrote anthems, chants, and psalm-tunes for the cathedral choir where he played. He became so popular from his real ability, coupled with pleasing manners, that he was occupied in teaching from fourteen to sixteen hours daily.

But he did more than this. As his hopes brightened, he determined to devote every minute to the pursuit of knowledge, in which he found his greatest happiness. He studied Greek and Italian. He would *unbend his mind,* after he retired, with Maclaurin's "Fluxions," or Robert Smith's "Complete System of Optics," and Lalande's Astronomy.

What if he had devoted this time to ease or amusement! Would he have become learned or distinguished? Every young man and woman is obliged to decide the matter for himself and herself. We cannot idle away life and be great.

In 1767, the fond father, Isaac, died of paralysis. Caroline, who loved him tenderly, was desolate. He had taught her the violin when the prosaic mother "was either in good humor, or out of the way." It is quite possible that music, like inventions, did not bring an adequate support for ten children, and that the practical mother wished her daughter to learn something whereby she could earn a living. She thereupon sent her two or three months to a seamstress to be taught to make household linen. After a time a delightful proposition came from the organist at Bath. He would take her to England, and see if she "could not become a useful singer

for his winter concerts and oratorios." If she did not succeed, after two years, he would carry her back to Germany.

In 1772, William came to Hanover and took his sister to Bath, at 7 New Kings Street. She was now twenty-two; an untutored girl, with a bright, eager mind, and a heart that went out to her brother in the most rapt devotion. History does not show a more complete, single-hearted, subservient affection, nor a sadder picture of a woman's sorrow in later years, in consequence of it.

At once Caroline began her work of voice culture, lessons in arithmetic, English, and in keeping accounts, from her brother, and in managing the house. Alexander, now in England, boarded with William, and he and Caroline occupied the attic. The first three winter months were lonely, as she saw little of William.

"The time," she says, "when I could hope to receive a little more of my brother's instruction and attention was now drawing near; for after Easter, Bath becomes very empty, only a few of his scholars, whose families were residents in the neighborhood, remaining. But I was greatly disappointed, for, in consequence of the harassing and fatiguing life he had led during the winter months, he used to retire to bed with a basin of milk or glass of water, and Smith's Harmonics and Optics, Ferguson's Astronomy, etc., and so went to sleep buried under his favorite authors; and his first thoughts on rising were how to obtain the instruments for viewing those objects himself of which he had been reading.

"There being in one of the shops a two-and-a-half-foot Gregorian telescope to be let, it was for some time taken in requisition, and served not only for viewing the heavens, but for making experiments on its construction. . . . It soon appeared that my brother was not contented with knowing what former observers had seen, for he

began to contrive a telescope eighteen or twenty feet long. . . . I was much hindered in my musical practice by my help being continually wanted in the execution of the various contrivances, and I had to amuse myself with making the tube of pasteboard for the glasses, which were to arrive from London, for at that time no optician had settled at Bath. But when all was finished, no one besides my brother could get a glimpse of Jupiter or Saturn, for the great length of the tube would not allow it to be kept in a straight line. This difficulty, however, was soon removed by substituting tin tubes."

Herschel had attempted to buy a telescope, but found the price far beyond his means. But he was not discouraged. Caroline soon saw "almost every room turned into a work-shop. A cabinet-maker making a tube and stands of all descriptions in a handsomely furnished drawing-room;" this could be so occupied when the music scholars had left Bath in their vacation; "Alex putting up a huge turning machine in a bedroom, for turning patterns, grinding glasses, and turning eye-pieces, etc."

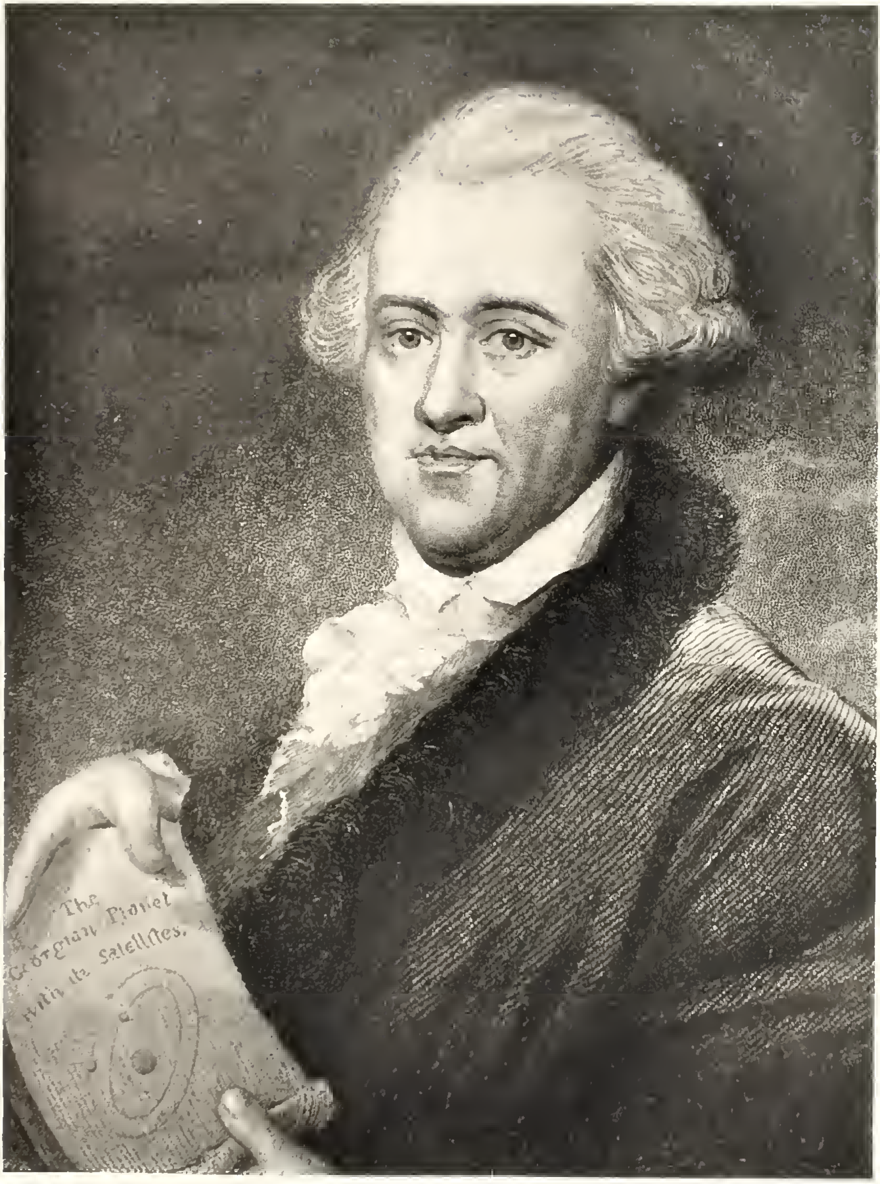
The longed-for time to see more of her brother never came to Caroline, except as she finally grew into his life-work, and became his second self.

He had one unalterable purpose, the study of the construction of the heavens. Nothing ever drew him from it. Nothing ever could draw him. And herein lay one of the elements of his great power. As an English writer has well said: "So gentle and patient a follower of science under difficulties scarcely occurs in the whole circle of biography." Yes, he was "gentle and patient," but with an untiring and never ending perseverance. Too poor to buy telescopes, he made them. With no time to read books during the day, he took the hours from sleep. With little opportunity for education, he educated himself.

In 1774, the music teacher made for himself a five-and-one-half-foot Gregorian telescope; and a year later, a Newtonian, with a four-and-a-half-inch aperture, which magnified two hundred and twenty-two times. The making of these instruments showed great mechanical skill and accurate knowledge. He began now to study the heavens in earnest, but the teaching must go on to provide daily bread. He directed an orchestra of nearly one hundred pieces, and Caroline copied the scores and vocal parts. So absorbed was he in his astronomical work, however, that at the theatre, between the acts, he would run from the harpsichord to look at the stars. This boyish eagerness and naturalness he kept through life.

He soon made a seven-foot reflector, then a ten-foot reflector. The mirrors for these telescopes were all made by hand, machines for the purpose not being invented till ten or more years later. Alexander, with his mechanical skill, assisted, and Caroline was always busy at work. She says, "My time was taken up with copying music and practising, besides attendance on my brother when polishing; since, by way of keeping him alive, I was constantly obliged to feed him, by putting his victuals by bits into his mouth. This was once the case, when, in order to finish a seven-foot mirror, he had not taken his hands from it for sixteen hours together. In general he was never unemployed at meals, but was always at those times contriving or making drawings of whatever came in his mind. Generally I was obliged to read to him while he was at the turning-lathe, or polishing mirrors, 'Don Quixote,' 'Arabian Nights' Entertainment,' the novels of Sterne, Fielding, etc.; serving tea and supper without interrupting the work with which he was engaged."

So busy that he could not find time to eat or sleep! Rare devotion of a rare mind! He now began to study



SIR WILLIAM HERSCHEL
From the portrait by J. Russell, R.A.

every star of the first, second, third, and fourth magnitudes in the sky. He carefully observed the moon, and measured the height of about one hundred of her mountains. Her extinct volcanoes, and her unpeopled solitudes, without clouds or air, were an impressive study.

He was now forty years old,—not young to begin the study of a new and illimitable science, but not too old, for one is never too old to begin a great or a noble work.

Through Dr. William Watson, Fellow of the Royal Society, who happened—if anything ever *happens* in this world—to see Herschel at his telescope, he became a member of the Philosophical Society of Bath, and soon in 1780 sent two papers to the Royal Society, the one on the periodical star in *Collo Ceti,* and the other on the mountains of the moon, which were read by Dr. William Watson, Jr.

When he was forty-three, he says, "I began to construct a thirty-foot aërial reflector, and, having made a stand for it, I cast the mirror thirty-six inches in diameter. This was cracked in cooling. I cast it a second time, and the furnace I had built in my house broke." But he persevered. This same year, 1781, after he had lived in Bath nine years, on the night of Tuesday, March 13, having removed to a larger house, 19 New King Street, he says, "In examining the small stars in the neighborhood of *H. Geminorum* I perceived one that appeared visibly larger than the rest; being struck with its uncommon appearance, I compared it to *H. Geminorum* and the small star in the quarter between Auriga and Gemini, and, finding it so much larger than either of them, I suspected it to be a comet."

The orbit of this "comet" was computed and its distance from the sun found to be eighteen hundred million miles! The world soon awoke to the fact that a new planet had been found, the greatest astronomical discovery

since Galileo invented the telescope, and the unknown musician at Bath had become famous! So little was Herschel known at this time, that one journal called him Mersthel, another Herthel, and still another Hermstel.

In December of the same year, 1781, Herschel was elected a Fellow of the Royal Society and received the Copley gold medal. He was no longer the poor German youth playing the oboe among the guards; he was the renowned discoverer. He called the planet Georgium Sidus, in honor of his sovereign, George III, but it was decided later to call it Uranus, from Urania the muse of astronomy.

Herschel went eagerly on with his work. Fame did not change his simple nature. The truly great are never ostentatious. He erected in his garden a stand for his twenty-foot telescope, and perfected his mirrors. "Though at times," says Caroline, "much harassed with business, the mirror for the thirty-foot reflector was never out of his mind, and if a minute could but be spared in going from one scholar to another, or giving one the slip, he called at home to see how the men went on with the furnace, which was built in a room below, even with the garden."

The next year, 1782, Herschel went to London, and met with a gracious reception from George III. He wrote back to his devoted sister:

DEAR LINA,

All my papers are printing, with the postscripts and all, and are allowed to be very valuable. You see, Lina, I tell you all these things. You know vanity is not my foible, therefore I need not fear your censure. Farewell.

I am your affectionate brother,

WM. HERSCHEL.

Again he wrote,—

I pass my time between Greenwich and London, agreeably enough, but am rather at a loss for work that I like. Company is not always pleasing, and I would much rather be polishing a speculum. . . . I am introduced to the best company. To-morrow I dine at Lord Palmerston's, next day with Sir Joseph Banks, etc., etc. Among opticians and astronomers nothing now is talked of but *what they call* my great discoveries. Alas! this shows how far they are behind, when such trifles as I have seen and done are called *great*. Let me but get at it again! I will make such telescopes, and see such things—that is, I will endeavor to do so.

And this great ambition nerved him for action, continued and laborious, as long as he lived. He was never satisfied; always achieving. Little can be expected from those who are easily satisfied.

George III wisely appointed Herschel Royal Astronomer, though with the too small salary of one thousand dollars yearly. He came back to Bath only to perform the last musical duty on Whit Sunday, 1782, the anthem for the day being his own composition, and to say good-bye to his pupils.

He moved to Datchet in 1782, and set up his twenty-foot telescope. In 1783, he made three reviews of the heavens. In 1784, he made a fourth review with his twenty-foot telescope. Caroline says: "My brother began his sweeps when the instrument was yet in a very unfinished state, and my feelings were not very comfortable when every moment I was alarmed by a crash or a fall, knowing him to be elevated fifteen feet or more on a temporary crossbeam, instead of a safe gallery. The ladders had not even their braces at the bottom; and one night, in a very high wind, he had hardly touched the ground before the whole apparatus came down. . . .

I could give a pretty long list of accidents which were near proving fatal to my brother as well as myself."

A gentleman who visited him at Datchet wrote: "The thermometer in the garden stood at 13° Fahrenheit; but in spite of this, Herschel observes the whole night through, except that he stops every three or four hours and goes in the room for a few moments. For some years Herschel has observed the heavens every hour when the weather is clear, and this always in the open air, because he says that the telescope only performs well when it is at the same temperature as the air. He protects himself against the weather by putting on more clothing. He has an excellent constitution, and thinks about nothing else in the world but the celestial bodies."

But, occupied as Herschel was about "celestial bodies," he yet found time to think about earthly things, for we find him at forty-five, May 8, 1783, marrying Mary, the wealthy widow of John Pitt, Esq., a lady of much intelligence and amiability.

The sad feature of the new relationship was the misery it brought to Caroline. Her whole life had centered in William. For eleven years she had devoted every moment, every wish, every thought to him. She had watched all night among the stars with him, month after month, year after year, in cold and in heat, and superintended his home by day. His every desire was her law. She loved no other, and he was her all. Perhaps she ought to have known that another might come into his life, but she trusted blindly, and did not question the future.

When the wife came into the home, Caroline went out of it forever. For more than twenty years she lived in lodgings, always "cheerless and solitary," her only happiness found in coming day by day to help her brother

in his great work. Sometimes, when the wife was absent, Caroline came back for a few days and lived over the old unalloyed life, and then went back to her lonely lodgings.

For ten years following this marriage, she probably told her heart-aches in her journal; but before her death she destroyed the record of these years, that the feelings of those who were alive might not be pained. In later days she became more reconciled to Lady Herschel, as "a dear sister, for as such I now know you," and idolized their only son, the renowned Sir John Herschel, born nine years after their marriage.

In 1785, Herschel began to construct his great forty-foot telescope, and the next year removed to Slough, not far from Windsor. "In the whole of the apparatus," he said, "none but common workmen were employed, for I made drawings of every part of it, by which it was easy to execute the work, as I constantly inspected and directed every person's labor; though sometimes there were not less than forty different workmen employed at the same time. While the stand of the telescope was preparing, I also began the construction of the great mirror, of which I inspected the casting, grinding, and polishing; and the work was in this manner carried on with no other interruption than that occasioned by the removal of all the apparatus and materials from where I then lived, to my present situation at Slough." He had his first view through the telescope February 19, 1787. George III gave twenty thousand dollars for the building of this instrument, and one thousand dollars yearly for its maintenance.

A half-century afterwards, the woodwork having become decayed, it was taken down, the great tube laid horizontally, and, after Sir John Herschel and his family had passed through it, a poem written by Sir John

having been read, it was sealed January 1, 1840, and placed on piers.

With this great telescope, Herschel discovered two satellites of Saturn, Mimas and Enceladus; one on August 27, 1789, and the other on September 17 of the same year. Two years before this, January 11, 1787, he discovered two satellites of Uranus, Oberon and Titania. Sixty years afterwards, Mr. Lassell, of England, discovered the remaining two satellites of Uranus, called Ariel and Umbriel.

From this time his work went forward grandly. He had already completed more than two hundred seven-foot, one hundred and fifty ten-foot, and eighty twenty-foot mirrors. For many of the telescopes sent abroad he made no stands, but provided the drawings. He wrote much about Saturn and its rings, and showed that its most distant satellite, Japetus, turns once on its axis in each revolution about its primary, as our moon does about the earth.

He studied carefully the nature of the sun, its probable gaseous surface, and its spots, and was the first to suspect their periodic character. What would Herschel have said to the wonderful photographic representations of these spots given by Professor Langley, in his New Astronomy; spots which are one billion square miles in size; more than five times the surface of the land and water on the earth? He saw, as astronomers today see, that heat cannot be produced without expenditure of force; and that the sun is probably cooling, even though scarcely perceptible for ages to come. He saw what science now generally concedes, the rise and fall of the solar systems; its gradual fitness for the coming of man, through almost countless centuries; and its final unfitness, when his generations shall have gone forever.

He wrote much about the Milky Way, believing at

first that it could be completely resolved into stars, about eighteen millions of them; but later he changed his theory, having found so much nebulous matter—in a state of condensation as though new worlds were forming, possibly to be the homes of some new race, or of man in the ages to come.

His study of the variable stars attracted wide attention. He found that the star *Mira Ceti* was for several months invisible to the naked eye; then it grew brighter and brighter, and finally disappeared for months, as before. He saw that other stars are periodic, and came to the conclusion that this is occasioned by the rotation of the star upon its axis, by which different parts of its surface are presented to us periodically.

He made a catalogue of double stars, and found by laborious calculations that such stars have a common centre of gravity; that one sun revolves about another. He found that our solar system has a motion of its own; a grand orbit round some as yet unknown centre, and that other systems have a like motion.

What this centre may be, whether a great sun like Sirius, one hundred times larger than ours, with unknown powers and unknown uses, is of course only conjecture.

Herschel gave much attention to nebulæ, discovering and describing twenty-five hundred new nebulæ and clusters. He gave his life to the study of the construction of the heavens. Concerning his statement of the general construction, Professor Holden, himself a brilliant astronomer, says: "It is the groundwork upon which we have still to build. . . . As a scientific conception it is perhaps the grandest that has ever entered into the human mind. As a study of the height to which the efforts of one man may go, it is almost without a parallel. . . . As a practical astronomer he remains with-

out an equal. In profound philosophy he has few superiors. By a kindly chance he can be claimed as the citizen of no one country. In very truth his is one of the few names which belong to the whole world."

The distinguished man, though unassuming and gentle in manner, must have had a realizing sense of the greatness of his work, for he said, "I have looked further into space than ever human being did before me. I have observed stars of which the light takes *two millions* of years to travel to this globe."

He gave much study to light and heat. So boundless was his knowledge believed to be, that a farmer called one day to ask the proper time for cutting his grass.

"Look at that field," said the scientist, "and when I tell you it is mine, I think you will not need another proof to convince you that I am no more weatherwise than yourself or the rest of my neighbors."

He worked earnestly till he was seventy-six, always depending upon his faithful and inseparable Caroline for aid in his labors. He made a telescope for her, with which she swept the heavens for comets, finding eight, five of which she discovered for the first time.

At seventy-six his health began to fail. He had worked incessantly from his struggling boyhood, but brain work does not wear us out; care and anxiety brings the marks of age upon us. He now took little journeys away from Slough for a change of scene and air, while Caroline stayed at home to copy his papers for the Royal Society, and to arrange his manuscripts. In 1816, he was made a knight of the Royal Hanoverian Guelphic Order, by the Prince Regent, and in 1821 was the first president of the Royal Astronomical Society, his son being its first foreign secretary.

In February, 1818, Caroline spent twelve precious days with her brother, "not in idleness," she says, but in

sorrow and sadness. He was not only unwell, but low in spirits." Later he went to Bath with Lady Herschel. "The last moments before he stepped into the carriage," says the loving Caroline, "were spent in walking with me through his library and workrooms, pointing with anxious looks to every shelf and drawer, desiring me to examine all and to make memorandums of them as well as I could. He was hardly able to support himself, and his spirits were so low, that I found difficulty in commanding my voice so far as to give him the assurance he should find on his return that my time had not been misspent.

"When I was left alone I found that I had no easy task to perform, for there were packets of writings to be examined which had not been looked at for the last forty years. But I did not pass a single day without working in the library as long as I could read a letter without candle-light, and taking with me papers to copy, etc., which employed me for the *best part of the night,* and thus I was enabled to give my brother a clear account of what had been done at his return."

On the 4th of July, 1819, Herschel sent a note to his dear co-worker. "Lina,—There is a great comet. I want you to assist me. Come to dine and spend the day here. If you can come soon after one o'clock we shall have time to prepare maps and telescopes. I saw its situation last night,—it has a long tail."

.Caroline wrote on this small slip of yellow paper: "I keep this as a relic! Every line *now* traced by the hand of my dear brother becomes a treasure to me."

Every day hereafter she spent the forenoon with Sir William. On the 15th of August she went as usual and found that he was confined to his room. "I flew there immediately," she says. "As soon as he saw me, I was sent to the library to fetch one of his last papers and a plate of the forty-foot telescope. But for the universe

I could not have looked twice at what I had snatched from the shelf, and when he faintly asked if the breaking up of the Milky Way was in it, I said 'Yes!' and he looked content. I cannot help remembering this circumstance, it was the last time I was sent to the library on such an occasion. That the anxious care for his papers and workroom never ended but with his life was proved by his frequent whispered inquiries if they were locked and the key safe, of which I took care to assure him that they were, and the key in Lady Herschel's hands.

"After half an hour's vain attempt to support himself, my brother was obliged to consent to be put to bed, leaving no hope ever to see him rise again. For ten days and nights we remained in the most heart-rending situation till the 25th of August, when not one comfort was left to me but that of retiring to the chamber of death, there to ruminate without interruption of my isolated situation. Of this last solace I was robbed on the 7th of September, when the dear remains were consigned to the grave."

Faithful and devoted watcher over his dead body, to the last! When he had been buried in the little church at Upton, Windsor, at the age of eighty-four, honored by all Europe and America, Caroline could live no longer where remembrance of him made it intolerable.

She went back to Hanover, "a person," she said, sadly, "that has nothing more to do in this world," to live with her brother Dietrich. She had come to England, a girl of twenty-two; she went back an elderly woman, seventy-two. The home in Germany did not prove a happy one, but how could it without William? She lived simply, not spending half of the five hundred dollars a year left her by her dead brother.

She had already published "A Catalogue of eight hundred and sixty Stars, observed by Flamstead, but not

included in the British Catalogue," and "A General Index of Reference to every Observation of every star in the above mentioned British Catalogue." She also prepared "The Reduction and Arrangement, in the form of a Catalogue in Zones, of all the Star Clusters and Nebulæ observed by Sir William Herschel in his Sweeps," "a work," said Sir David Brewster, "of immense labor; an extraordinary monument of the unextinguished ardor of a lady of seventy-five in the cause of abstract science."

For this the Royal Astronomical Society voted her the gold medal, and gave her the unusual distinction of honorary membership.

Sixteen years after her return to Hanover, Sir John Herschel, her nephew, who had made his wonderful review of the southern heavens, discovering as many new nebulæ as his father, took his only boy, Willie, to see her.

She was now eighty-eight. The visit was overwhelming to her affectionate heart. She watched the child with the most intense delight. Fearing the results if she knew the time of their departure for England, Sir John, with mistaken kindness, went away at four o'clock in the morning, without saying good-bye. But the anguish of separation was thereby rendered greater.

The years went by slowly. On her ninety-sixth birthday the King of Prussia sent her a gold medal, Alexander von Humboldt writing her a letter from Berlin to accompany it.

January 14, 1848, at the age of almost ninety-eight, Caroline Herschel died, and was buried from the same garrison church where nearly a century before she had been christened. In her coffin was placed, by her desire, a lock of her brother's hair. Beautiful affection! great co-workers in their immortal study of unnumbered worlds!

BARON CUVIER

In the town of Montbéliard, France, then belonging to the Duke of Würtemberg, August 23, 1769, was born the founder of the Science of Comparative Anatomy; the greatest naturalist of his time, Georges Léopold Chrétien Frédéric Dagobert Cuvier. His father was a brave officer in a Swiss regiment, who at fifty married a young lady of unusual ability. Their first son died, and the second, Georges, was so feeble in constitution that his life was saved only by the tenderest care of his mother.

For this mother the boy cherished the most ardent affection. While she lived, there was nothing left undone that a loving nature could do for her. When she died, everything connected with her memory became sacred. When Cuvier had become honored by kings and nobles, when the great from all the world delighted to bring him offerings, nothing so touched his heart as the gift of a bouquet of red stocks, her favorite flower. Perchance the benignity that came into his face in later years was the result of these sweet remembrances.

She taught him to read at four, and, though ignorant of Latin, she made him repeat his lessons to her daily, so that he was the best prepared of any boy in school. She read to him history and general literature. She made him draw under her inspection. She talked with him about books till a passion for reading became the chief characteristic of his nature. No wonder that he loved such an inspiring woman. The history of most great men emphasizes the fact that the mothers cannot be too highly educated. At ten years of age he was placed in

a high school, called a gymnasium, where for four years he studied Latin, Greek, history, geography, and mathematics, and was constantly at the head of his classes. Naturally enthusiastic, he played as heartily as he studied.

As is often the case, a book turned the course of his life, and made him famous. At the gymnasium he found a work of Gesner, the Swiss naturalist, and this, with its colored plates, first turned his attention to natural history. This liking was intensified by finding at the house of a relative the complete works of Buffon, the noted naturalist, who wrote thirty-six volumes in his own brilliant and poetic style, describing the animal kingdom. The boy became intensely interested in the habits of quadrupeds and birds; their form, their color, and their homes. He copied the illustrations in the work, and colored them with paint or pieces of silk. He always carried a volume of Buffon in his pocket to read when he had a moment of leisure. At twelve, he was a well-read naturalist.

In his last year in the school, when he was fourteen, he chose a certain number of his school-fellows, and formed an Academy. Every Thursday he gathered the lads into his room, and placing them around a table, seated himself upon his bed, and after some book had been read on natural history, philosophy, history, or travels, he asked their opinions of it, and then, being president, summed up the argument in a clear and concise manner. The mother's seed-sowing in the mind of her ardent boy was bearing fruit.

As the family were poor, and had only a soldier's pension to support them, it was decided that Georges should enter the free school at Tübingen, and prepare for the church. But the principal of the gymnasium, who had never forgiven the boy for some playful trick, placed his composition in the third rank. Georges knew that it

deserved the first rank, and that this low standard would affect his position in college. He, therefore, resolved not to enter Tübingen, and, though he was thereby lost to the church, he was saved for great scientific work.

A fortunate thing now happened. A woman, a princess, who knew about the bright boy, spoke of him to her brother, Duke Charles of Würtemberg. When the duke visited Montbéliard, he sent for the lad, questioned him as to what he had learned, asked to see his drawings, and ended by sending him free of expense to the University of Stuttgart, to enter his own Academy, called the Academy Caroline. It seemed a little thing for a lady to speak of a boy's studiousness and great love of books, but it proved a great thing for Georges Cuvier and for the scientific world. Thousands of women and men could do more of these little acts of kindness, if they only thought of it. Well said Thomas Hood:—

> Evil is wrought by want of thought,
> As well as want of heart.

The boy of fourteen said good-bye to his devoted mother, and started for Stuttgart, seated between the Chamberlain and the Secretary of the Grand Duke. Both spoke German all the way, and the lonesome boy did not understand a word. He entered the Academy May 4, 1784, and for four years studied mathematics, law, philosophy, finance, and the like.

But he lost no opportunity to study natural history. A professor gave him the works of Linnæus, and he gained inspiration from the young man who could travel four thousand miles through the marshes of Lapland, nearly barefoot and half-starved, in his study of plants. Georges now collected a herbarium. When he had leisure, he drew and colored insects, birds, and flowers with

great accuracy. He kept a number of living insects in his room, constantly feeding them and watching their habits. He said years afterward, "If I had not studied insects from choice, when I was at college, I should have done so later, from a conviction of its necessity." He declared that the wonders he met with in the organization of insects always elevated his thoughts.

Nine months after his arrival in Germany, he won the prize at the Academy for excellence in the German language, receiving the order of Chevalerie, an honor given only to five or six out of four hundred pupils. This entitled the recipients to dine at a separate table, and to enjoy many advantages under the immediate patronage of the Grand Duke.

When the four years of college life were over, the father's pension having ceased on account of the disturbed financial condition of France, the youth of eighteen needed to find employment at once. Nothing seemed open to him but the position of tutor in a private family, a thing much deprecated by his school-fellows, who had already built many air-castles for his future.

But young Cuvier had the courage and the wisdom to do what necessity required, and to do it cheerfully. In July, 1788, he entered the family of Count d'Héricy in Caen, Normandy, and for six years taught his only son. He took with him, says a friend, "these admirable foundations for glory: a love of labor, depth of reflection, perseverance, and uprightness of character." While teaching here, he met the nobility of the surrounding country, increasing thereby his polish of manner and tact, for which he was celebrated all his life.

Living by the sea, he was led to study marine animals. The casual dissection of a calamar, a species of cuttle-fish, influenced him to study the anatomy of mollusca, which afterward led to his great classification of the whole

animal kingdom. In this obscure corner of Normandy, the young teacher observed, and committed his observations to paper. Some young men would not have found time for such work. Those only succeed who have sufficient force of character to make time for what they wish to do. To allow one's time to be wasted, is to allow one's opportunities for eminence to go by forever.

Nearly every evening Cuvier attended a small society of which he was secretary, which gathered chiefly to discuss agricultural and kindred topics. M. Tessier, living there in exile under an assumed name, the author of several valuable articles in the Encyclopedia, was often present, and between him and the young secretary a warm friendship soon existed. As the friendship of the Marquis Guidubaldo proved valuable to Galileo, so that of M. Tessier proved of great benefit to Cuvier. He led the young and comparatively unknown naturalist, though some of his articles had been published in learned journals, to correspond with Geoffroy St. Hilaire, De Lacépède, and others on scientific subjects. Through their influence he was finally called to Paris, made a member of the Commission of Arts, and professor at the Central School of the Panthéon.

He was only twenty-six, and this was but the beginning of honors. Here he composed his "Elementary Treatise on the Natural History of Animals." His great desire was to be attached to the Museum of Natural History, where he could study the collections and enlarge them. Very soon after his arrival in Paris, M. Mertrud was appointed to the newly created chair of Comparative Anatomy at the Jardin des Plantes. He was advanced in years. And now came the opportunity for friendship to do its work. Geoffroy St. Hilaire and De Lacépède were his colleagues. They urged that their friend Cuvier be appointed assistant, and Mertrud gladly

BARON CUVIER
From an original drawing

consented. This was indeed an honor, since Daubenton, Buffon, Lamarck, and other European celebrities had filled this position.

Cuvier at once sent for his aged father, now nearly eighty years old, and his only brother, Frédéric, to make their home with him. The precious mother had died two years previously. She did not live to see the fame of her eldest son, but she must have been convinced of his future greatness, and been comforted by the prospect.

From the moment of entering upon his new work, Cuvier began to develop that wonderful collection in comparative anatomy which is now so celebrated. Nothing ever turned him from his purpose of making this the most extensive collection in the world; no sorrow, no legislative duties, no absence. No one who has visited Paris will ever forget the seventy-five acres in the Jardin des Plantes, with trees and flowers from all the world; with thirteen rooms filled with skeletons and anatomical preparations of all kinds; with eleven rooms in the gallery of anthropology containing every variety of the human species, in casts, mummies, and fossils; with the gallery of zoölogy containing over two thousand mammalia, belonging to five hundred species, as many reptiles, ten thousand birds, and over twenty-five hundred fishes; with immense geological, mineralogical, and botanical collections; all a marvel of industry and learning.

Cuvier now worked unceasingly. Sometimes his salary was in arrears, but he bore it cheerfully, as he wrote a friend: "You are not to suppose that Paris is so highly favored; for twelve months' pay are now due at the Jardin des Plantes, and all the national establishments for public instruction, in Paris as well as at Strasburg; and if we envy the elephants, it is not because they are better paid than we are, but because while living on credit, as we do, they are not aware of it, and consequently are

insensible to the pain it gives. You know the saying about the French, that when they have no money they sing. We savants, who are not musicians, work at our sciences instead of singing, which comes to the same thing." He is a hero, indeed, who can breast poverty, and work and sing in the midst of hardship. When he published his "Annals of the Museum," he not only drew, but often engraved the plates himself, when he was unable, for lack of means, to hire it done.

The National Institution was founded in 1796, and Cuvier was associated with his friends De Lacépède and Daubenton, in the section of zoölogy, holding the position of Secretary of Natural Sciences till his death.

Four years later, in 1800, the first two volumes of his "Lessons in Comparative Anatomy" were published, and met with great success. The last three volumes were issued five years later.

In this year, 1800, Cuvier received another honor, that of the professorship of Natural Philosophy in the Collège de France. He was now but thirty-one. The following year, Napoleon I, who was usually wise in his selection of men, appointed him one of the six inspectors-general of education, to establish public schools in thirty towns of France.

Every moment now seemed occupied, and yet while the brain was busy perchance the heart was lonely. The father had died two years after the mother. The wife of his brother Frédéric had died, also, and the two brothers were left alone. At thirty-four, Cuvier decided to take into his heart and home the widow of M. Duvaucel, Fermier-Général, who had perished on the scaffold in 1794. The family had lost all their money in the French Revolution, and Madame Duvaucel had four large children to be supported; but Cuvier loved her for her rare mind and sweet disposition, and she blessed

the remaining years of his life. An educated man needs companionship in mind; not simply a housekeeper.

Six years later one of her sons was assassinated in Portugal, during the retreat of the French army. Another, while collecting for the museum of Paris, died in Madras, a young man of great talent and much beloved. A daughter, Mlle. Duvaucel, lived to be the comfort of Cuvier's declining years.

Happy in his home and absorbed with his work, Cuvier went forward to new labors and new honors. M. Mertrud had died, and, instead of being assistant at the Jardin des Plantes, Cuvier was now professor. In 1808 Napoleon made him counsellor for life of the Imperial University. The next year he organized new academies in the Italian States, which were now annexed to France. In 1811 he was sent on a similar mission to Holland and the Hanseatic towns, and was made a chevalier, which rank was assured to his heirs. Though he disliked to be absent from his family, he went where duty called him, and wrote back fond letters to his wife.

MY TENDER FRIEND,

The weather, the road, the horses, and the postilions have proved so excellent that we have reached Porte Sainte Mayence before six o'clock; and I have bitterly regretted the two or three good hours that I might still have passed with thee, without in the least delaying my journey. At least believe that I have passed them in my imagination, and that the remembrance of thy caresses and tender friendship will form the happiness of my whole way.

After some words to the children, he added:

We are quite well, my good friend; we have crossed an agreeable country; and we are in a tolerable inn. Our carriage appears to be quite able to bear the journey; thus, up

to this moment, all goes well. Pray to God that this may last; thou art so good that he cannot refuse thee. Adieu. A thousand tender kisses. G. C.

This year, 1811, appeared one of his most important works—that on "Fossil Remains," which wrought a revolution in the study of geology. By comparing living and fossil animals, Cuvier showed that huger creatures had lived on the earth and become extinct before the creation of man. In the first epoch he found great reptiles, like the Ichthyosaurus, thirty feet long, and the Megalosaurus, seventy feet long. In the second epoch, he found the Paleotherium; in the third, the Mammoth, Mastodon, and gigantic sloth; and in the fourth epoch, man. So closely had he studied the relations of the organs of animals, that he could reconstruct the extinct fossil from a single bone. He had already prepared, at the request of Napoleon, a brilliant "Report on the Progress of Natural Sciences from the year 1789."

In 1813, though a Protestant, he was sent to Rome to organize a university, and was made Master of Requests in the Council of State. Napoleon also appointed him Commissaire Impérial Extraordinaire, and sent him to endeavor to raise the people on the left bank of the Rhine in favor of France, against the invading troops then marching upon them. But Cuvier was stopped at Nancy by the entrance of the allied armies, and obliged to return.

He was now famous, and his company and counsel were sought by the learned and the great. And he was still a comparatively young man, forty-four.

But life had great sorrows in the midst of this prosperity. His first child, a son, had died a few weeks after his birth. His daughter Annie had died in 1812, at the age of four, and now in 1813, while he was absent in Rome, his only son, Georges, a boy of seven, had been

taken from him. The blow was a terrible one. For many years he never saw a boy near that age, without being deeply affected. He would stop on the streets to watch a group of boys playing, and then go on sadly, thinking of the one he had buried.

In 1814 Cuvier was raised to the rank of Counsellor of State, and Chancellor of the University. When Napoleon was asked why he had appointed a savant to a political position, he replied, "that he may be able to rest himself sometimes," knowing that to a man like Cuvier change was the most helpful rest. When Napoleon abdicated his throne, and Louis XVIII came to power, Cuvier was retained in office, for his rare administrative ability, and upright life.

Three years later, the first edition of his "Animal Kingdom" appeared, and is now to be seen in the British Museum, in seventeen volumes. This work has served as the basis for subsequent zoölogical classification. Cuvier studied minutely the interior structure of animals, and based his classification on this, instead of exterior resemblance.

After this great work was published, Cuvier went with his family to London, for a rest of six weeks. Here he received distinguished attention from Sir William Herschel, and other learned men.

In 1819, he was appointed President of the Committee of the Interior, and in this position, which he held for life, it is believed ten thousand various matters passed through his hands each year, for his examination and decision. He officiated at the crowning of Charles X, as one of the presidents of the Council of State, and received from that monarch the decoration of Grand Officer of the Legion of Honor. His former sovereign, the King of Würtemberg, appointed him Commander of the Order of the Crown.

All this time in which he was doing earnestly and responsible work for his country, he was writing and lecturing almost constantly. So careful was he of his time, that he always read or wrote as he was riding in his carriage through the streets of Paris. A lamp in the back of his carriage he used at night, till he found that he was injuring his eyes. Even while he was sitting for a portrait, to be used as a frontispiece for his book, "Discourse on the Revolutions of the Globe," his wife's daughter read to him the "Fortunes of Nigel." In the evenings, when he was too tired for scientific research, his wife or daughter read to him general literature.

Every Saturday evening a reception was held at the home of Baron Cuvier, and there one was sure to meet the most brilliant and learned from all parts of Europe, whether rich or poor.

Cuvier delighted everybody by his courtesy and his cordiality. Another person also was the life of these gatherings,—his beautiful daughter Clementine, his only remaining child. Never strong in body, she had been reared with the tenderest care. Devoted to all good work, such as reading to aged women and visiting the poor, and of extreme loveliness of character, she was the idol of her family and of society. On the 25th of August, 1828, she was to have been married, but, while in the midst of the preparations, she fell ill of consumption, and died the following month, September 28.

The effect on both parents was crushing. Cuvier's light hair grew white, and lines gathered in his face. After two months he took his place again at the head of the Committee of the Interior. He listened attentively to all the discussions, but when it came his turn to speak, he burst into tears, and covered his bowed face in his hands, and sobbed bitterly. Finally he raised his head and said, "Pardon me, gentlemen, I was a father, and I

have lost all!" and then with a violent effort he resumed the business of the day, with his usual calmness.

He devoted himself now more than ever to his books, as though he must use every moment, or be prostrated with grief. This same year, 1828, the first book in a series of twenty volumes, beautifully illustrated, appeared, on the "Natural History of Fishes, containing more than five thousand species of those animals, described after nature, and distributed according to their affinities, with observations on their anatomy, and critical researches on their nomenclature, ancient as well as modern."

In 1832, he was created a Peer of France, by Louis Philippe. Every honor had come that could be asked or desired. His books were eagerly read; crowds attended his lectures; he was loved, honored, and revered; but death had robbed him of the sweetest things in life.

On Tuesday, May 8, 1832, he lectured as usual before the Collège de France, on the "History and Progress of Science in all Ages." In the evening he felt a numbness in his right arm. It was the beginning of the end. Paralysis soon developed.

He said to M. Pasquier, President of the Chamber of Peers, "Behold a very different person to the man of Tuesday—of Saturday. Nevertheless, I had great things still to do. All was ready in my head; after thirty years of labor and research, there remained but to write; and now the hands fail, and carry with them the head."

M. Pasquier tenderly expressed the universal interest felt for M. Cuvier. "I like to think so," said the dying man; "I have long labored to render myself worthy of it." He is to be pitied, indeed, who does not care whether the world loves him.

On May 13, the nomination of Cuvier to the presidency of the whole Council of State was taken to the sovereign for his signature, but it came too late. Cuvier died that

day. Four hours before his death he had asked to be taken into the room where he had met and talked with so many of the renowned of earth, and where his Clementine had charmed them by her presence. And there he died.

He was buried in Père la Chaise, by his own request, under the tombstone which covered Clementine, and whose death had virtually caused his own. His coffin was borne by the pupils of the different colleges in which he had taught, thousands following it to the cemetery. His library of nineteen thousand volumes was purchased by the government for the Jardin des Plantes. There was no child left to bear his titles.

Not only do the books of such a man live; his whole life, with its untiring energy, its promptness, its order, its unfaltering purpose, its high aims, as well as its tenderness and nobility of heart, is a constant inspiration.

ALEXANDER VON HUMBOLDT

The great Agassiz, in his eloquent address, in Boston, on the hundredth anniversary of the birth of Humboldt, said: "All the fundamental facts of popular education in physical science, beyond the merest elementary instruction, we owe to him. We are reaping daily in every school throughout the broad land, where education is the heritage of the poorest child, the intellectual harvest sown by him.

"There is not a text-book of geography, or a school atlas in the hands of our children to-day, which does not bear, however blurred and defaced, the impress of his great mind. But for him our geographies would be mere enumerations of localities and statistics. He first suggested the graphic methods of representing natural phenomena which are now universally adopted. The first geological sections, the first sections across an entire continent, the first averages of climate illustrated by lines, were his. Every school-boy is familiar with his methods now, but he does not know that Humboldt is his teacher."

Naturally we ask how such a man rose to fame, and what incited him to stand among the few intellectual leaders of the world.

Frederick William Henry *Alexander* von Humboldt was born September 14, 1769, in Berlin, the same year as Baron Cuvier. Unlike Cuvier, he came into a home of wealth and culture. His father was a Prussian officer and chamberlain to the king. His mother, the widow of Baron von Hollwede, married Major von Humboldt

when he was forty-six years old, bringing into the family much landed property. Three children were born to them, a daughter who died in infancy, and the famous brothers, William and Alexander, the former two years older than the latter.

The father, an exceedingly amiable and benevolent man, died when Alexander was but ten years old. The mother, left with her two sons, was wise enough to select superior tutors for them, deeming a good education their best preparation for a useful life.

Much of their time was spent at their summer home at Tegel, on the banks of the Havel, about eight miles from Berlin. In 1778 Goethe went there for a visit, and the two Humboldt lads, nine and eleven years of age, played and talked with the leading mind of Germany.

The children were not altogether happy there, as Alexander wrote a friend years afterward. "Vine-clad hills which here we call mountains, extensive plantations of foreign trees, the meadows surrounding the house, and lovely views of the lake with its picturesque banks awaiting the beholder at every turn, render this place undoubtedly one of the most attractive residences in the neighborhood. If, in addition, you picture to yourself the high degree of luxury and taste that reigns in our home, you will indeed be surprised when I tell you that I never visit this place without a certain feeling of melancholy. . . . I passed most of that unhappy time (my youthful days) here at Tegel, among people who loved me, and showed me kindness, but with whom I had not the least sympathy, where I was subjected to a thousand restraints and much self-imposed solitude, and where I was often placed in circumstances that obliged me to maintain a close reserve, and to make continual self-sacrifices.

"Now that I am my own master, and living here without restraint, I am unable to yield myself to the charms

of which nature is here so prodigal, because I am met at every turn by painful recollections of my childhood, which even the inanimate objects around me are continually awakening. Sad as such recollections are, however, they are interesting from the thought that it was just my residence here which exercised so powerful an influence in the formation of my character and in the direction of my tastes to the study of nature."

Much which seems trying and unsatisfactory is, after all, our best discipline for life. The strongest and noblest characters are not developed in the perpetual sunshine of happiness. Rain and sun are alike necessary for growth.

Alexander early showed fondness for natural history, collecting flowers, plants, butterflies, shells, and stones, so that he was called the "Little Apothecary." He likewise found great delight in drawing. He says of himself: "Until I reached the age of sixteen, I showed little inclination for scientific pursuits. I was of a restless disposition, and wished to be a soldier. This choice was displeasing to my family, who were desirous that I should devote myself to the study of finance, so that I had no opportunity of attending a course of botany or chemistry; I am self-taught in almost all the sciences with which I am now so occupied, and I acquired them comparatively late in life. Of the science of botany I never so much as heard till I formed the acquaintance in 1788 of Herr Willdenow, a youth of my own age, who had just been publishing a Flora of Berlin. His gentle and amiable character stimulated the interest I felt in his pursuits. I never received any lessons professedly, but I used to bring him the specimens I collected, and he gave me their classifications. I became passionately devoted to botany, and took especial interest in the study of cryptogamia. The sight of exotic plants, even when only as dried specimens

in an herbarium, fired my imagination with the pleasure that would be derived from the view of a tropical vegetation in southern lands."

At sixteen, then, the boy did not know for what he was best fitted in life. How important for young men and women to study themselves, and know their own tastes and capacities! At nineteen he had never heard of botany, and yet he became one of the most distinguished of botanists!

The boy also longed to go to sea, not an unusual desire in restless and ambitious natures. But he was frail in body, and gave little evidence that he would ever be able to accomplish any of the things for which he longed.

At nineteen he was ready for college, and with his brother entered at Frankfort-on-the-Oder. He gave his time largely to finance and political economy, by his mother's desire, that he might be able to act in some capacity under the government.

At college, as ever after in life, he found one devoted friend, who became his inseparable companion. At Frankfort, it was Wegener, a young theologian, with a warm heart, and great zeal for knowledge. Nor did this friendship cease when he went to Göttingen some months later, for better opportunities in the study of science. He wrote to Wegener: "If God only spare us, nothing can break the bond between two friends who are to each other more than brothers. . . . My fervent love and sincere friendship for you are as imperishable as the soul which gives them birth. . . . How happy, how inexpressibly happy should I be, if I had a friend like you by my side! . . . I doubt not that among eight hundred men there be some with whom I could form a friendship, but how long is it often before we find each other out! Were not you and I acquainted for three months before we discovered how completely we were made one for the other?

To be without a friend, what an existence! And where can I hope to find a friend whom I could place by your side in my affections!"

These words seem like those of a lover, or an affectionate woman, but they come from a mind that now, as in after years, towered like a giant oak in the trees of a forest. Beautiful union of brain and heart! Such only makes an ideal character.

Humboldt had already met Willdenow, and begun to love botany. Again he writes to Wegener: "I have just come in from a solitary walk in the Thiergarten,"—he was for a short time in Berlin,—"where I have been seeking for mosses, lichens, and fungi, which are just now in perfection. How sad to wander about alone! And yet there is something attractive in this solitude, when occupied with nature. . . . I am collecting materials for a work on the various properties of plants, medicinal properties excepted; it is a work requiring such great research, and such a profound knowledge of botany, as to be far beyond my unassisted powers, and I am therefore endeavoring to enlist the coöperation of several of my friends. . . . Pray do not imagine that I am going to appear as an author forthwith; I do not intend that shall happen for the next ten years, and by that time I trust I shall have discovered something startlingly new and important."

Göttingen was now at the height of its glory. Humboldt attended courses of lectures on archæology, on trade and commerce, on light, heat, and electricity, on agriculture, and on ancient tragic poets, under Heyne, of whom he said, "Heyne is undoubtedly the man to whom this century is the most deeply indebted; to him we owe the spread of religious enlightenment, by means of the education and training he has instituted for young village school-masters; to him is due the introduction of a

more liberal tone of thought, the establishment of a literary archæology, and the first association of the principles of æsthetics with the study of philology."

Humboldt was also fond of Greek. He said, "The more I know of the Greek language, the more am I confirmed in my preconceived opinion, that it is the true foundation for all the higher branches of learning."

With some friends, he soon founded the Philosophical Society, which, with the admirable libraries and museums at hand, became of great assistance to the students.

The next year, 1790, he had become so interested in science, that he wrote Wegener: "I was away from Göttingen for two months, spending the vacation in making a scientific tour with a Herr van Genns, a Dutchman, with whom I became acquainted through his writings on botanical subjects. . . . Amid the numberless distractions of the journey, which was made sometimes on foot and sometimes by carriage, and with the incessant occupation of packing up minerals and plants, I was not very well able to write to you." The result of this tour was a pamphlet, "Mineralogical Observations on some Basalts of the Rhine." His next works were two small treatises, "The Aqueous Origin of Basalt," and "The Metallic Seams in the Basalt at Unkel." And this youth of twenty-one was self taught both in mineralogy and geology!

The wonder was not so great, perhaps, that a young man of his age should have written these sketches, as that, being wealthy and of the best social position, the temptations to ease and enjoyment did not draw him away from such subjects. Poverty may not be a delight, but the larger part of the world's work has been done under its stimulus. Wealth should be an incentive, because it

gives leisure for study, but this is not always the case.

At Göttingen, Humboldt found a friend among the eight hundred. At the house of Heyne he made the acquaintance of George Foster, Heyne's son-in-law, a man who exerted a remarkable and lasting influence over him. Foster was thirty-six; Humboldt, fifteen years his junior. He had been around the world with Captain Cook in his second voyage, and had published an able book upon the subject. He was skilled in chemistry, philosophy, literature, and politics, understood Latin, Greek, French, English, Dutch, and Italian, and was somewhat conversant with the Swedish, Spanish, Portuguese, Russian, and Polish languages.

The influence of such a man can well be imagined. He became a guiding star to the young Göttingen student. If we could but estimate the value of right friendships in life! We flatter ourselves that we are too strong to be influenced, and yet we are greatly influenced for good or for evil by those with whom we associate. Humboldt always chose intellectual friends, and the natural result followed.

In the spring of 1790, he left Göttingen, and, with Foster and Van Genns, took a journey to the Lower Rhine, Holland, Belgium, England, and France, studying docks, mines, botanic gardens, manufactures, and churches, and visiting literary celebrities. Still the new friends did not take the place of the old, for he writes to Wegener: "I beseech you, dearest Wegener, by all the affection which you know I bear you, never to forget our brotherly love and friendship. You are infinitely more to me than I can ever be to you. I have now seen the most celebrated places in Germany, Holland, and England—but, believe me, I have in seeing them never been so happy as while sitting in Steinbart's arm-chair."

The influence of this journey was never lost. Sixty-eight years afterward, Humboldt said: "For the space of thirty years I have never known leisure but of an evening, and the half-century that I have spent in this ceaseless activity has been occupied in telling myself and others how much I owe my teacher and friend George Foster in the generalization of my views on nature, and in the strengthening and development of that which had already dawned in me, before those happy days of intimate friendship."

In the latter part of 1790, Humboldt went to Hamburg, to enter the School of Commerce. He wished to study political economy further, and to learn practical book-keeping. He wrote to a friend: "I am contented with my mode of life at Hamburg, but not happy, less happy even than at Göttingen, where the monotony of my existence was relieved by the society of one or two friends and the vicinity of some moss-grown mountains. I am, however, always contented when I feel that I am accomplishing the purpose I have in view. . . . My leisure hours are occupied with geology and botany. . . . In addition, I have begun to learn Danish and Swedish."

To Wegener he writes: "I have made considerable progress in general information, and I am beginning to be somewhat more satisfied with my attainments. I worked very hard at Göttingen, but all I have learned makes me feel only the more keenly how much remains still to know. My health suffered severely, but improved somewhat during my journey with Foster; yet even here I continue so closely occupied that I find it difficult to spare myself. There is an eager impulse within me, which often carries me, I fear, beyond the bounds of reason; and yet such impetuosity is always necessary to insure success."

The "eager impulse" was a sure indication of something to be accomplished by and by. Success does not

come with half-hearted effort; it comes only through a force and persistence that will allow no barriers between us and the goal.

At Easter, 1794, Humboldt left Hamburg and hastened to the famous School of Mines at Freiberg, to study under the celebrated Werner. Here, as ever, he attached one ardent friend to himself, Freiesleben, a student in geology. Here every moment was occupied. He studied the works of the French chemists; Guyton de Moreau, Fourcroy, Lavoisier, and Berthollet. He was daily in the mines, from six o'clock till twelve. He crowded six lectures into each afternoon. He made a study of the vegetation of that lower world, from which the sunlight is ever excluded, and the results were used later in his comprehensive work, "Flora Subterranea Fribergensis." He wrote articles for several scientific journals. A busy life, indeed, for the young man of twenty-two!

His friend Freiesleben says of Humboldt at this time:—

"The salient points of his attractive character lay in his imperturbable good-nature, his benevolence and charity, his remarkable and *unselfish amiability,* his susceptibility of friendship and appreciation of nature; simplicity, candor, and the absence of all pretension characterized his whole being; he possessed conversational powers that made him always lively and entertaining, together with a degree of wit and humor that led him sometimes to waggishness. It was these admirable qualities which in later years enabled him to soften and attach to himself the untutored savages, among whom he dealt for months at a time, which obtained for him in the civilized world admiration and sympathy wherever he went, and which gained for him, while a mere student, the esteem and devotion of all classes at Freiberg.

"He was kindly disposed towards every one, and knew how to make himself useful and entertaining in every

circle of society; and it was only against every species of inhumanity and coarseness, against every kind of insolence, injustice, or cruelty, that he ever manifested either scorn or indignation."

How the world loves "unselfish amiability;" a person who goes through life thinking for others, not irritable, not supersensitive, not censorious!

On Humboldt's return to Berlin in 1792, he was at once made "Assessor in the Administrative Department of Mines and Smelting Works," a position for which he had previously applied. As a rule, places do not seek persons, however brilliant; they must seek places.

This was a fine opening for a young man, not yet twenty-three. He went to work with unbounded energy. He investigated the general form of mountains, collected information as to former methods of working the mines, by having three chests of mining documents, belonging to the sixteenth century, brought to him for careful study, and made a report on the salt, alum, and vitriol works, and on the porcelain manufactory. The government authorities were so pleased with his thorough report that he was appointed superintendent of mines in the two Franconian duchies.

He wrote to Freiesleben:

I am quite intoxicated with joy. . . . Do not feel anxious about my health; I shall take care not to over-exert myself, and after the first the work will not be heavy. I cannot conclude without acknowledging that it is again to you that I am indebted for this happiness; indeed I feel it only too keenly. What knowledge have I, dear Freiesleben, that has not been taught me by you! . . . How sweet is the thought to me that it is to you that I owe all this; it seems as if it bound me closer to you, as if I carried something about me that had been planted within me and cultivated by yourself.

Thus all through life was the appreciative, warm-hearted man glad to show his gratitude for the stimulus of intellectual friends.

Who does not love to be appreciated! How many of us wait to say kind things to our friends until death makes it impossible!

Again he wrote: "I possess a certain amount of vanity, and am willing to confess it; but I know the power of my own will, and I feel that whatever I set myself to do I shall do well."

While so earnestly engaged in study, Humboldt, with his benevolent heart, could not see the children of the miners grow up in ignorance. He therefore opened free schools for them, and paid the teachers from his own purse. Not many young men at twenty-four would have thought of so admirable a plan.

Meantime he was experiencing the first keen joy of fame. The Elector of Saxony had sent the author of "Flora Fribergensis" a gold medal. The Swedish botanist Vahl had named a magnificent species of an East Indian laurel after him, the *laurifolia Humboldtia.* It had paid to be a student; to be led by the "eager impulse" within him.

The next year he wrote to Freiesleben:—

You are aware that I am quite mad enough to be engaged upon three books at once. . . . I have discovered several new lichens. I have also been occupied upon the history of the weaving of the ancients. . . . My head is quite distracted with all I have to attend to—mining, banking, manufacturing, and organizing; . . . the mines, however, are prospering. . . . I am promoted to be counsellor of mines at Berlin, with a salary, probably, of fifteen hundred thalers (here I have four hundred), and, after remaining there a few, months, I shall most likely be appointed director of mines, either in Westphalia or Rothenburg, and receive from two

thousand to three thousand thalers. I tell you everything, and open my heart to you.

In 1795, having resigned his position in the service of the state, because of his desire for travel and scientific work, with two friends, Freiesleben, and Lieutenant Reinhard von Haften, of Westphalia, he journeyed to Venice, going through Tyrol and the Alps into Switzerland. They visited the mountains around Schaffhausen, Zürich, and Berne, and such notable men of science as De Luc, Pictet, and Saussure. As Freiesleben said: "No subject having any reference to the physical constitution of the earth, the atmosphere, or any point of natural history, was allowed to escape his attention."

An especial bond united Humboldt and the highly educated Von Haften, since between the latter's sister Minette and the young scientist there existed a devoted affection. This was cherished for ten years, but Humboldt's life of travel and exposure prevented a union which both ardently desired. He sacrificed his affections to science, and the loneliness of his later years proved the unwisdom of his choice.

On his return home, Humboldt set himself earnestly to the writing of two books: one on geology, the disposition of strata in mountain masses; the other on the "Excitability of the Nerves and Muscles," describing over four thousand experiments. His devotion to science was shown by the painful experiments upon his own body, which brought permanent harm to his nervous system. He wrote to a friend:

I applied two blisters to my back, each of the size of a crown-piece, and covering respectively the trapezius and deltoid muscles. . . . When the blisters were cut, and contact made with zinc and silver, I experienced a sharp pain, which was so severe that the trapezius muscle swelled consid-

erably, and the quivering was communicated upwards to the base of the skull and the spinous processes of the vertebræ.

He also experimented with the noxious gases in mines, inventing lamps which were the forerunner of Sir Humphry Davy's. Sometimes he was deprived of consciousness by the gases and saved only by the timely aid of friends.

Always longing for foreign travel, he went to Weimar, to make himself more fully ready for it, especially by the study of anatomy. Here lived his brother William, who had married a brilliant and intellectual woman, the intimate friend of the wife of Schiller.

Here Humboldt and Goethe became earnest friends. Goethe says: "During Humboldt's visit, my time has been usefully and agreeably spent; his presence has had the effect of arousing from its winter sleep my taste for natural science." Years afterward Goethe said to Eckermann: "Alexander von Humboldt has been with me for some hours this morning; what an extraordinary man he is! Though I have known him for so long, I am always struck with fresh amazement in his company. He may be said to be without a rival in extent of information and acquaintance with existing sciences. He possesses, too, a versatility of genius which I have never seen equalled. Whatever may be the subject broached, he seems quite at home in it, and showers upon us treasures in profusion from his stores of knowledge. He resembles a living fountain, whence flow many streams, yielding to all comers a quickening and refreshing draught. He will remain here a few days, and I already feel that I shall have lived through years in the time."

That Humboldt valued this friendship is shown by the dedication to Goethe of the first part of his "Travels in America."

The project of foreign travel was long delayed by sickness, war, and various disappointments. But, in life, obstacles are the common lot of mortals, and he alone is wise who breasts them cheerfully, patiently, and persistently. Humboldt said, "It is impossible not to feel the severity of this disappointment; but it is the part of a man to work, and not to yield to unavailing regrets."

> Hard! well, and what of that?
> Didst fancy life one summer holiday,
> With lessons none to learn, and naught but play?
> Go, get thee to thy task. Conquer or die!
> It must be learned. Learn it then, patiently.

At last, in 1799, when Humboldt was thirty, the long contemplated journey to South America was about to be realized. He had already published some astronomical treatises on the determination of latitudes, trigonometrical measures of the Alpine ranges, etc.; had given lectures in Paris, before the National Institute, on the nature of nitrous gas, and the possibility of a more exact analysis of the atmosphere; and had spent some time in Spain, with the well known botanist Bonpland, in collecting plants, and making observations in connection with meteorology, geology, and magnetism. While at Madrid, through Herr von Forell, a distinguished patron of science, Humboldt was received at court and obtained permission of the king to visit the Spanish colonies in America.

At his own expense, the best scientific instruments were procured, and June 5, 1799, at two o'clock in the afternoon, he and Bonpland, with their crew and a few others, sailed away, in the corvette *Pizarro,* for a five years' journey. He sent tender farewell messages back to "his family," as he called William's children, and

then stifled any feelings of loneliness or homesickness which he had in his heart, by his favorite motto, "Man must ever strive after all that is good and great."

June 20, they were at the foot of the Peak of Teneriffe. He wrote to his brother: "I am quite in a state of ecstasy at finding myself at length on African soil, surrounded by cocoanut palms and bananas. . . . I returned last night from an excursion up the peak. What an amazing scene! What a gratification! We descended some way into the crater, perhaps farther than any previous scientific traveller. . . . What a remarkable spectacle was presented to us at this height of eleven thousand five hundred feet. . . . At two in the morning we were already on our way towards the last cone. The heavens were bright with stars, and the moon shone with a gentle radiance; but this calm was soon to be disturbed. The storm raged violently round the summit; we were obliged to cling fast to the edge of the crater. The wind rushed through the rifts with a noise like thunder, while a veil of cloud separated us from the world below."

After the voyage of nineteen days, the ship entered the harbor of Cumana, on the north coast of South America. Here they enjoyed the new and strange scenes; the houses built of satin-wood; the copper-colored Indians outside the town, living in bamboo huts, covered with the leaves of the cocoanut palm; these great trees from fifty to sixty feet high, with large red bunches of flowers. "Even the crabs," said Humboldt, "are sky-blue and gold!"

By November they had dried more than sixteen hundred plants, and described about six hundred new varieties. He had taken observations of the solar eclipse of October 28, and so severely burnt his face that he was obliged to remain in bed for two days.

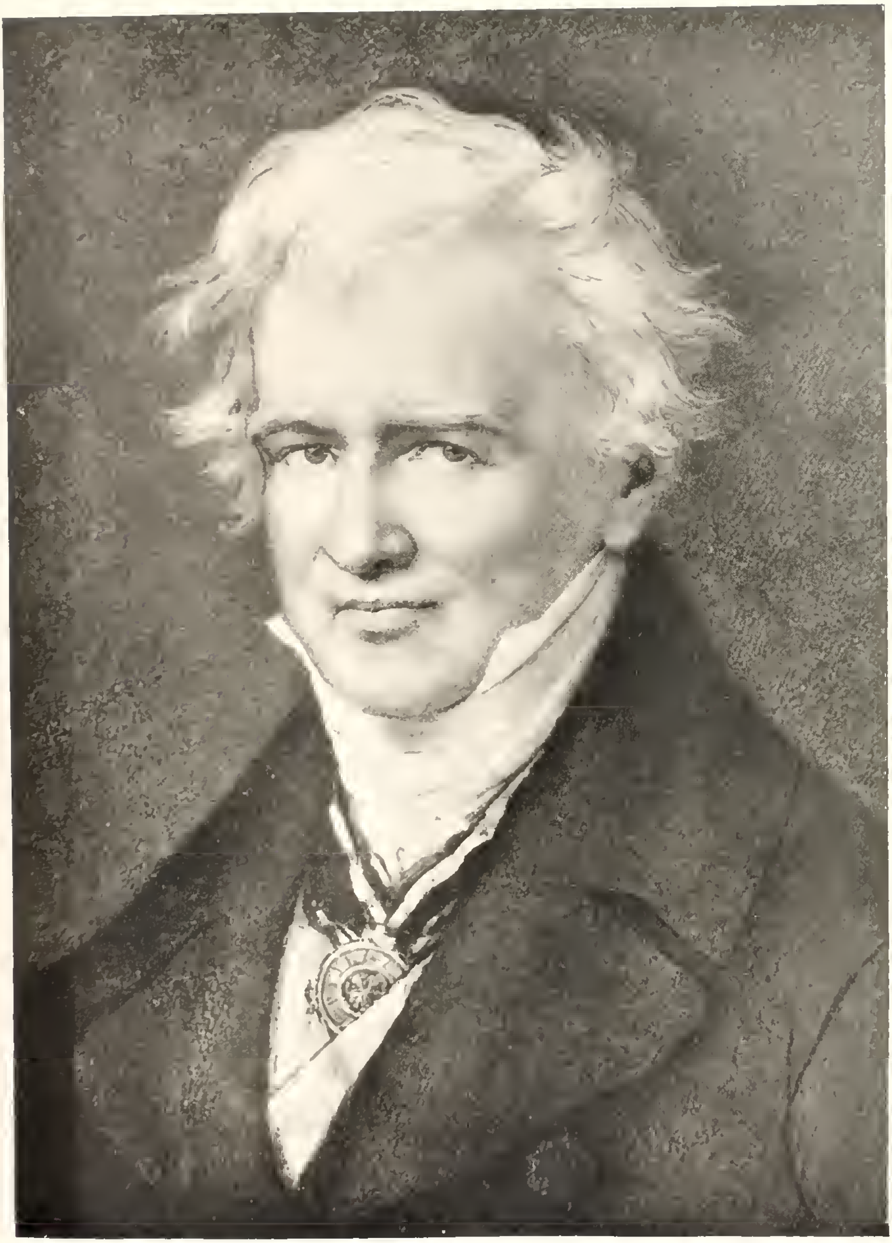
Going to Caracas, they spent two months and a half

climbing mountains, visiting hot springs, and forming an intimate acquaintance with tigers, crocodiles, monkeys, and boa constrictors. Here they discovered the singular cow-tree, with dry and tough leaves, but which gives out a sweet nourishing milk when an incision is made in its stem. "At sunrise this vegetable spring is the richest: then the negroes and the natives come from all sides, provided with large vessels to collect the milk, which turns yellow and thickens on the surface."

In February, 1800, the travellers traced the water system of the Orinoco, often in the midst of danger. Once, in a severe storm, their boat was two-thirds full of water. "Our position," says Humboldt, "was truly appalling; the shore was distant from us more than a mile, where a number of crocodiles could be discerned lying half out of the water. Even if we had gained the shore against the fury of the waves and the voracity of the crocodiles, we should infallibly have either perished from hunger or been torn in pieces by the tigers, for the woods upon these shores are so dense and so intertwined with lianas as to be absolutely impenetrable. The strongest man, axe in hand, could hardly make his way in twenty days for the distance of a league. The river too is so little frequented that even an Indian canoe scarcely passes oftener than once in two months. At this most momentous and perilous crisis a gust of wind filled the sails of our little vessel and effected in a marvellous manner our deliverance."

To his botanist friend, Willdenow, he writes:—

During four months of this journey we passed the night in forests, surrounded by crocodiles, boa constrictors, and tigers, which are here bold enough to attack a canoe, while for food we had nothing better than rice, ants, bananas, and occasionally the flesh of monkeys, with only the waters of the Orinoco wherewith to quench our thirst. Thus have we



ALEXANDER VON HUMBOLDT

with difficulty toiled, our hands and faces swollen with mosquito bites, from Mondvaca to the volcano of Duida, from the limits of Quito to the frontier of Surinam—through tracts of country extending over twenty thousand square miles, in which no Indian is to be met with, and where the traveller encounters only apes or serpents.

In Guiana, the mosquitoes abound in such clouds as to darken the air, and, as it is absolutely necessary to keep head and hands constantly covered, no writing can be done by daylight; the intolerable pain produced by the attacks of these insects renders it impossible to hold the pen steadily. All our work had therefore to be carried on by the light of a fire, in an Indian hut, where no ray of sunlight could penetrate, and into which we had to creep on our hands and knees. Here, if we escaped the torment of the mosquitoes, we were almost choked by the smoke. At Maypures, we and the Indians took refuge in the midst of the cascade, where the spray from the foaming stream kept off the insects. At Higuerote, the people are accustomed at night to lie buried three or four inches deep in sand, with only the head exposed.

Sometimes twenty-four Indians were in Humboldt's employ for months together, and fourteen mules were required to carry his instruments and plants.

After a year and a half spent in South America, Humboldt sailed for Cuba, where he remained for several months, collecting material for his "Political Essay on the Island of Cuba." From there he went to Quito, in Ecuador, crossing one of the most difficult passes in the Andes, "the path so narrow that it rarely exceeds twelve or sixteen inches in width, and for the most part resembles an open gallery cut in the rock," and the Paramos of Pasto, "desert regions where, at a height of about twelve thousand feet above the sea, all vegetation ceases, and the cold is so intense as to penetrate to the very bones."

In June, 1802, they reached Quito, where, five years

previously, an earthquake had destroyed forty thousand people. This month they made the ascent of Chimborazo, at that time regarded as the highest mountain in the world. "At certain places," he says, "where it was very steep, we were obliged to use both hands and feet, and the edges of the rock were so sharp that we were painfully cut, especially on our hands." As they climbed on, "one after another, we all began to feel indisposed, and experienced a feeling of nausea accompanied by giddiness, which was far more distressing than the difficulty of breathing. . . . Blood exuded from the lips and gums, and the eyes became bloodshot. . . . A few rock-lichens were to be observed above the line of perpetual snow, at a height of sixteen thousand nine hundred and twenty feet; the last green moss we noticed was growing about twenty-six hundred feet lower. A butterfly was captured by M. Bonpland, at a height of fifteen thousand feet, and a fly was observed sixteen hundred feet higher. . . . When we were at a height of about seventeen thousand four hundred feet we encountered a violent hailstorm." The height of the mountain is over twenty-one thousand feet.

The intrepid Humboldt four times crossed the Andes; he travelled over Peru; he called attention to the fertilizing properties of guano, and then he sailed for Mexico, where he remained for a year. Here he met a lady greatly esteemed in that country, called the "fair Rodriguez," the most beautiful woman he had seen in his journeys, but whom he admired more "for her graces of mind than her beauty of person." He regarded her as an American Madame de Staël. It is asserted that the grave man of science was deeply interested, but it was too late—she was already the wife of another, and had two children. Humboldt, like most other great men, all his

life enjoyed the society of intellectual women, who were a constant inspiration.

After two months passed at Havana, Humboldt came to the United States, spending three weeks with President Jefferson, at his home at Monticello. He never failed to speak in grateful terms of the courtesy he received from Americans. He studied carefully our institutions, and greatly admired the republic; slavery alone saddened him.

On July 9, 1804, after five years of absence, he set sail for France. Europe received him with universal joy. He had been reported dead. He was thirty-five, handsome, and famous. He had travelled over forty thousand miles, and brought back over sixty thousand specimens of plants. He was made a member of the Royal Academy of Sciences in Berlin, and later a member of the Legion of Honor, and of about one hundred and fifty other societies; indeed, of all the great associations of the land.

And now the result of his travels must be given to the world in books. While he was preparing them, he yet found time to spend months together in the École Polytechnique, experimenting in chemistry with his devoted friend Gay-Lussac; with Biot, he made investigations in magnetism; with Arago, in astronomy; with Cuvier, in anatomy.

Most of the time from 1808 to 1827, nineteen years, he remained in Paris, devoting his time to his great work. In the forenoons he usually studied and experimented; from twelve to seven he wrote, and then, if his evenings were spent socially, he wrote again from midnight till half-past two, usually allowing himself only four hours for sleep. So popular was he that he often went to five receptions in an evening.

Year after year his works on America appeared, till

twenty-nine volumes were published! The first part was entitled, "Voyage in the Equatorial Regions of the New Continent." This described a portion of his journey in three volumes; views of the Cordilleras and the native peoples of America, one volume with sixty plates; an atlas of the new continent, with thirty-nine maps; a critical examination of the history of the geography of the Middle Ages, in five volumes. The second part related largely to zoölogy and comparative anatomy in the new regions; the third part related chiefly to Mexico; the fourth part to astronomical observations, measurement with the barometer, etc.; the fifth part, geology, and the geography of plants; the sixth part, plants in Mexico, Cuba, and South America, in two volumes, with nearly one hundred and fifty engravings; two volumes more, with one hundred and twenty colored plates; seven volumes of new species, with seven hundred engravings, and several other books. The expense of bringing out these works was enormous; the copper-plate illustrations cost in printing and paper alone about one hundred and seventy thousand dollars.

As the price of the volumes was about twenty-seven hundred dollars, the number of purchasers was comparatively limited. Humboldt had used all his fortune in his journeys and in publishing his books, and was now a poor man, dependent upon a pension from his king. But he was the pride of his nation, and beloved in France as well.

Humboldt and Guizot were like brothers, and for forty years corresponded affectionately with each other. Arago he held "dearest in this life." His last letter to Arago, "small in size but so full of matter," was the greatest comfort to the dying astronomer.

During all these busy twenty years he had honors heaped upon him. He was offered the position of Am-

bassador to Vienna, but declined. He accompanied the King of Prussia to England in 1814, and was with him at the peace of Aix-la-Chapelle and at the Congress of Verona.

Busy as he was, he seemed to find time to befriend everybody, especially young men. Liebig says in the preface of his work dedicated to Humboldt: "During my residence in Paris, I gave a course of lectures at the Academy in the winter of 1823–4, upon an analytic investigation of Howard's fulminating mercury and silver —my first effort in the field of science.

"At the close of the sitting of March 22, 1824, while busy packing up my apparatus, a gentleman came up to me from among a group of academicians, and entered into conversation. In the most winning manner, he made inquiry as to the objects of my study, my present occupations, and the plans I had laid for the future. We separated without my knowing to whom I was indebted for this kind expression of interest, for my shyness and inexperience had not allowed me to make the inquiry.

"This conversation laid the foundation of my future career, for I thus acquired a kind friend and a powerful patron in my scientific undertakings. . . .

"From that time all doors were thrown open to me, I had access to every institution and every laboratory: the great interest you took in me procured the love and intimate friendship of my instructors, Gay-Lussac, Dulong, and Thénard, to all of whom I became deeply attached. The confidence which you accorded me was the means of my introduction into a sphere of labor which during the last sixteen years it has ever been my ambition worthily to occupy."

When Agassiz was a poor medical student in Paris, Humboldt visited him. Agassiz says:—

"After a cordial greeting, he walked straight to what

was then my library—a small book-shelf containing a few classics, the meanest editions, bought for a trifle, along the quays, some works on philosophy and history, chemistry and physics, his own 'Aspects of Nature,' 'Aristotle's Zoölogy,' 'Linnæus' Systema Naturæ,' in several editions, 'Cuvier's Règne Animal,' and quite a number of manuscript quartos, copies which, with the assistance of my brother, I had made of works I was too poor to buy, though they cost but a few francs a volume. . . .

"It was no doubt apparent to him that I was not over-familiar with the good things of this world, for I shortly afterward received an invitation to meet him at six o'clock in the Galerie Vitrée of the Palais Royal, whence he led me into one of those restaurants the tempting windows of which I had occasionally passed by. When we were seated, he half laughingly, half inquiringly, asked me whether I would order the dinner. I declined the invitation, saying that we should fare better if he would take the trouble. And for three hours, which passed like a dream, I had him all to myself. How he examined me, and how much I learned in that short time! How to work, what to do, and what to avoid; how to live; how to distribute my time; what methods of study to pursue; these were the things of which he talked to me on that delightful evening."

Noble Humboldt! so great that everybody honored and looked up to him; so kindly interested in others that everybody loved him!

In 1827, at the request of his king, Humboldt returned to Berlin, and became chamberlain, with a yearly salary of five thousand thalers. He gave this year, before the university, a course of free, public lectures upon physical geography, sixty-nine in all, which afterwards formed the basis of his grandest work, "Cosmos." The first

four lectures were a general description of nature; then astronomy, the principal outlines of geology and meteorology, the distribution of plants and animals, the history of the study of our globe, volcanoes, the ocean, the atmosphere, and the human race.

The lectures were crowded and the applause unexampled. A second course, of sixteen lectures, was given to the public in the music hall, the royal family coming with the thousands who gathered each evening.

A grand way to educate the people! Would that at the expense of some philanthropist such a course might be given in every city.

In 1829, at the request of Emperor Nicholas, Humboldt made a scientific expedition to eastern Russia, travelling oven nine thousand miles in twenty-five weeks. He was now in his sixtieth year, but he climbed high mountains with no apparent fatigue.

The emperor was delighted with the results of the expedition, which were published in several volumes. He said, "Your sojourn in Russia has been the cause of immense progress to my country; you spread a life-giving influence wherever you go." He presented Humboldt with a sable cloak worth five thousand rubles, and a malachite vase seven feet high, worth nearly forty thousand rubles.

The death of friends saddened this busy year, 1829. William's wife had died, and left him utterly desolate. In his ministry to several countries, she had honored and graced his diplomatic positions. He did not long survive her. "Wholly given up to grief," said Alexander, "he seeks in the depth of his misery the only consolation that can render life supportable, while he occupies himself with intellectual pursuits as with the drudgery of a task."

He died four years later, tenderly watched over by

his illustrious brother, to whom he said in dying, "Think of me often, but always with cheerfulness. I have been very happy, and even today has been a glorious day with me, for there is nothing more beautiful than love. I shall soon be with *the mother,* and enter upon a higher order of being."

This death was a great blow to Alexander. He said, "I am quite bereft of hope. I did not think that my old eyes could have shed so many tears. . . . I am the unhappiest of men. . . . I have lost half of myself." A few months later William's eldest daughter, Caroline, died, to whom Alexander was tenderly attached. From henceforth his life was devoted to his sovereign Frederick William IV, to "Cosmos," and to his ever-widening circle of friends. Two thousand letters or more came to him yearly, and till late in life he answered each one, and answered it promptly, showing thereby how truly well-bred in manner, and how truly kind in heart.

In 1834, when he was sixty-five, he began the publication of "Cosmos," in five volumes, the "most comprehensive compendium of modern science." It was soon translated into English, meeting with a cordial reception in that country, and into French, Dutch, and Italian.

Even at the age of sixty-five, so eager was he to know more that he attended courses of lectures on Grecian antiquities and literature, and upon chemistry, taking notes among the young university students. He now lived with the king, at Sans-Souci, spending every evening with him, and becoming the confidential friend of both king and queen. When Humboldt was ill, the king would read to him by the hour.

Frederick William IV conferred on him the decoration of the Star of the Red Eagle, the Order of the Black Eagle, the highest honor in the royal power to confer, and the Order of Merit, given to those "who throughout

Europe have won for themselves a name either in the arts or sciences."

Till the last years of his life Humboldt showed the same marvellous energy and industry. At eighty he said, "I am more than ever filled with a zest for work and literary distinction." When he wrote to friends for information in finishing "Cosmos," he asked for speedy answers, saying, "The dead ride fast." On the fortieth anniversary of his return to Europe, a fête was given in his honor, by the Berlin Academy. Later his bust was placed in the French Institute. The freedom of the city of Berlin was presented to him. America sent him in 1858, on his eighty-ninth birthday, an album of nine maps, showing the scores of towns, counties, rivers, bays, and mountains which had received his name. Letters came from all parts of the world, breathing love and admiration. Yet, with all this honor, he was often lonely, and spoke of the *ennui* of life. After the regency, Humboldt lived at Berlin, in an unostentatious home, with his attendant, Seifert.

On May 6, 1859, at half-past two in the afternoon, death came to Alexander von Humboldt, at the age of ninety. His mind was clear to the last. All ranks gathered at the public funeral, for all, from king to peasant, had lost a friend. With uncovered head, the Prince Regent received the procession at the door of the cathedral, amid the tolling of the bells, and then they buried him at the summer home of his childhood, Tegel, by the side of William.

A new edition of his select works, including "Cosmos," was published in Stuttgart, in 1874, in thirty-six volumes.

Great in learning, great in achievement, great in will-power; unwise sometimes in utterance, as in the Varnhagen letters—how seldom is it safe or wise to express our inmost thoughts; sarcastic sometimes in his language

—a dangerous power, to be used sparingly, if indeed ever,—and yet withal a noble, unselfish, marvellous-minded man, who, as Agassiz says, "exerted upon science a personal influence which is incalculable."

SIR HUMPHRY DAVY

Coleridge said, "Had not Davy been the first chemist, he probably would have been the first poet of his age."

Said Professor Silliman's "American Journal of Science and Arts:" "His reputation is too intimately associated with the eternal laws of nature to suffer decay; and the name of Davy, like those of Archimedes, Galileo, and Newton, which grow greener by time, will descend to the latest posterity."

Davy was poor and self-taught, but he triumphed over obstacles, and died universally lamented.

The eldest son in a family of five children, Humphry Davy was born at Penzance, Cornwall, England, December 17, 1778, the year in which Carl Linnæus died. He was a bright, active child, making rhymes when he was five years old, and reciting them at the Christmas gatherings. In consequence of his retentive memory, he could repeat a great part of "Pilgrim's Progress" before he could read it. This book and "Æsop's Fables" were his favorites.

When Humphry was six, he was sent to a grammar school kept by Rev. Mr. Coryton, a man who had the vicious habit of punishing by pulling the pupil's ears. On one occasion, Humphry came to school with a large plaster on each ear. Upon being asked what was the matter, he said with a grave face, that he had "put the plasters on to prevent a mortification!"

As he grew older, he composed Latin and English verses easily, and was in great demand among the boys

as a writer of valentines and love-letters. Though shy in manner, with his vivid imagination and flow of language, he told stories remarkably well, and might have been seen, often, in a cart at the Star Inn, addressing a most attentive audience.

Says his brother, Dr. John Davy, "Humphry, when a boy, was fond of declaiming, and indulged in it in his solitary walks and rambles. On one occasion it is recorded of him, that, on his way to visit a poor patient in the country (during his apprenticeship), in the fever of declamation, he threw out of his hand a vial of medicine which he had to administer, and that when he arrived at the bedside of the poor woman he was surprised at the loss of it. The potion was found the next day in a hay-field adjoining the path."

When Humphry was fourteen he attended the Truro Grammar School for a year, where he was greatly liked for his good-humor, affectionate disposition, and originality. Says Mr. Nicholls, a school friend, "I can never forget that as boys we knew and loved each other. I recollect a visit he paid in company with his aunt at my father's, who then resided at Lanarth. He was a great favorite; but there was even then an original mode of thinking and acting observable in him,—one instance of which I well remember; it was on rather a hot day, when my father, mother, your aunt, Humphry, and myself, were to walk to a place a mile or two distant, I forget for what purpose. Whilst others complained of the heat, and whilst I unbuttoned my waistcoat, Humphry appeared with his great-coat close-buttoned up to his chin, for the purpose, as he declared, of keeping *out* the heat. This was laughed at at the time, but it struck me then, as it appears to me now, an evincing originality of thought and an indisposition to be led by the example of others."

At fifteen his school education was considered complete.

The next year he studied French, gave a good deal of time to fishing, of which he was always fond, and apparently had little definite purpose. About this time his father died, and the straitened circumstances of the family now seemed to awaken all the energy and nobility of his nature. Seeing his mother in deep affliction, he begged her not to grieve, saying that *"he would do all he could for his brothers and sisters."* And he never forgot this promise.

The following year he was apprenticed to Mr. Bingham Borlase, practising surgeon and apothecary in Penzance. Young Davy now seemed destined to become a physician, but his note-books show that he intended to know other things besides medicine. He laid out a plan for study: theology, logic, astronomy, mathematics, Latin, Greek, Italian, Spanish, and Hebrew.

He said later, "Almost all great deeds arise from a plenitude of hope or desire. No man ever had genius who did not aim to execute more than he was able." And all his life he planned to do twice as much as he was ever able to do. And yet he knew that he must bind himself to a *few* things, if he would succeed. He said, "In minds of great power, there is usually a disposition to variety of pursuits, and they often attempt all branches of letters and science, and even the imitative arts; but if they become truly eminent, it is by devotion to one object at a time, or at most two objects. This sort of general power is like a profusion of blossoms on a fruit tree, a symptom of health and strength; but if all are suffered to become fruit, all are feeble and bad; if the greater portion is destroyed by accident or art, the remainder, being properly nourished, become healthy, large, and good." In these early note-books, he began to show an unusual and mature mind. He wrote essays: "On the Immortality and the Immateriality of the Soul," "On

Governments," "On Moral Obligation," and the like. Of Friendship, he wrote at seventeen: "It is a composition of the noblest passions of the mind; a just taste and love of virtue, good-sense, a thorough candor and benignity of heart, and a generous sympathy of sentiment and affections, are the essential ingredients of this nobler passion. When it originates from love and esteem, is strengthened by habit, and mellowed by time, it yields infinite pleasure, ever new and ever growing. It is the best support amongst the numerous trials and vicissitudes of life, and gives a relish to most of our enjoyments. What can be imagined more comfortable than to have a friend to console us in afflictions, to advise with us in doubtful cases, and share our felicity? . . . It exalts our nobler passions, and weakens our evil inclinations; it assists us to turn the race of virtue with a steady and undeviating course. From loving, esteeming, and endeavoring to felicitate particular people, a more general passion will arise for the whole of mankind."

He finishes this essay with an allegory. God is described as deliberating with the angels on the propriety of creating woman. Justice, Peace, and Virtue plead against her creation, as through her Adam will be driven out of Paradise. Then Divine Love stands before Jehovah, her countenance covered with smiles. "Create her," she says, "for Paradise itself will afford no delight to man without woman. She will be the cause of his misery, but she will likewise be the cause of all his happiness. She will console him in affliction; she will comfort and harmonize his soul; she will wipe the tears from his eyes, and compose the fury of his passions. Her friendship shall make him virtuous, and her love shall make him happy; and, lastly, the tree of their transgression, and the plant of immortality, nourised by the blood of her son, shall flourish, and grow out of Paradise, and overspread

the earth: man shall eat of their fruit, and be immortal and happy."

All through these early note-books are scattered his poems, showing a passion for the blue sea at Penzance, and an unbounded love of nature.

Just as he was entering his nineteenth year, young Davy began the study of chemistry, as a branch of his profession. He read "Lavoisier's Elements of Chemistry," and "Nicholson's Dictionary of Chemistry." Suddenly a new world seemed to open before him. He began to think for himself, and to make experiments. As his means were limited, his apparatus consisted of vials, wine-glasses, tea-cups, tobacco-pipes, and earthen crucibles.

His first experiments were the effects of acids and alkalies on vegetable colors, the kind of air in the vesicles of common seaweed, and the solution and precipitation of metals. These were made in his bedroom in Mr. Tonkin's house, or in the kitchen, when he required fire. This old gentleman had brought up his mother and her two orphan sisters, and now was like a father to Humphry. He said, "This boy, Humphry, is incorrigible. Was there ever so idle a dog! He will blow us all into the air." He was at this time probably making a detonating composition, which he called "thunder power," his sister Kitty being his assistant.

At this time, a young man came to board at the house of Mrs. Davy, Gregory Watt, the only child of James Watt, the inventor of the steam-engine. He was the idol of his parents; possessed of a mind so unusual in its passionate love for knowledge, and a nature so companionable, that everybody loved him. He was twenty-one, and Humphry nineteen.

Between these two young men there grew a most ardent and lasting friendship; lasting because it had the only sure foundation, moral and mental worth. They

were always together. They visited the neighboring mines and mountains, and came home with their pockets filled with minerals.

The brilliant Gregory died at twenty-eight, but Davy lived to show the fruits of one of the most beautiful things in life, the affinity of two noble and intellectual souls, with similar tastes and aspirations. This death was a great loss to Humphry. He wrote to a friend: "Poor Watt! He ought not to have died. I could not persuade myself that he would die: and until the very moment when I was assured of his fate, I would not believe he was in any danger.

"His letters to me only three or four months ago were full of spirit, and spoke not of any infirmity of body, but of increased strength of mind. Why is this in the order of nature, that there is such a difference in the duration and destruction of her works? If the mere stone decays, it is to produce a soil which is capable of nourishing the moss and the lichen; when the moss and the lichen die, and decompose, they produce a mould, which becomes the bed of life to grasses, and to more exalted species of vegetables. Vegetables are the food of animals; the less perfect animals of the more perfect; but in man the faculties and intellect are perfected. He rises, exists for a little while in disease and misery; and then would seem to disappear, without an end, and without producing any effect.

"We are deceived, my dear Clayfield, if we suppose that the human being, who has formed himself for action, but who has been unable to act, is lost in the mass of being; there is some arrangement of things which we can never comprehend, but in which his faculties will be applied. . . . Gregory was a noble fellow, and would have been a great man. Oh! there was no reason for his dying—he ought not to have died."

SIR HUMPHRY DAVY
From the portrait by H. Howard

This death broke the spirit of James Watt, the father, who ever after kept beside him, in the attic at Heathfield, the little, old-fashioned hair trunk of his beloved Gregory, full of his school-books, letters, and childish toys. It stands today, where it did eighty years ago, beside the mouldering beams of the sculpture machine. That life is not short, however few the years, which leaves such an undying influence and such beautiful memories.

Humphry was now twenty-six, and much had come into his young life. He had applied himself with zeal to his professional studies, had read Locke, and Rollin, and Gibbon, and Shakespeare, and at twenty had been appointed to take charge of the Pneumatic Institution at Clifton, established by Dr. Beddoes. It had been founded to give an opportunity of trying the medicinal effects of various gases, and was supported by liberal men of science. So distressed was his old friend, Mr. Tonkin, that he should give up the idea of being a surgeon in Penzance, that he revoked a legacy he had made him in his will!

Davy's life was now an extremely busy one. He published, when he was twenty-one, his "Essays on Heat and Light," beginning his work, like Sir Isaac Newton, when but a youth. He discovered silica in the epidermis of the stems of weeds, corn, and grasses. He found the intoxicating effects of breathing nitrous oxide, April 9, 1799, and his experiments on this subject were published the following year. He spent ten months of incessant labor in them, often endangering and once nearly losing his life from breathing carburetted hydrogen. He made experiments on galvanic electricity, increasing the powers of the Galvanic Pile of Volta. He also planned and partly wrote an epic poem on the deliverance of the Israelites from Egypt.

Worn with overwork, he returned to see his widowed

mother at Penzance. He had been absent a year. How glad were all to greet the rising young scientist! Not least glad was Davy's water spaniel, Chloe. When very small, and about to be drowned, he begged her as a gift, and with great care reared her to be his hunting and fishing companion. At first she did not know him, but when, with his peculiarly musical voice, he called her by name, "she was in a transport of joy."

Davy never forgot his early life at Penzance. In his will he left a sum of money to be paid annually to the master of the grammar school, *"on condition that the boys may have a holiday on his birthday."*

One secret of Davy's early success was, no doubt, his ambition. He used to say that he had been kept largely from the temptations of youth by "an active mind, a deep ideal feeling of good, and *a look towards future greatness."* The young man or woman who definitely plans to be somebody seldom finds any obstacles along the road too great to be overcome.

He wrote in his note-book: "I have neither riches, nor power, nor birth recommended me; yet, if I live, I trust I shall not be of less service to mankind, and to my friends, than if I had been born with these advantages."

At the Pneumatic Institution he found in Mrs. Beddoes "the best and most amiable woman in the world," a helper in the development of his genius. Like the wife of William Humboldt, and like any other woman who combines heart and intellect, Mrs. Beddoes gathered about her, in her home, Coleridge and Southey, and other bright minds of Clifton. Here Davy, scarcely more than a boy, with his soft brown curling hair, his beautiful smile, and his "wonderfully bright eyes, which seemed almost to emit a soft light, when animated," in the midst of congenial friends, was stimulated to do his best.

Years after this, Wordsworth gave Dr. John Davy

a letter to Coleridge, on the back of which he had written: "This from Davy, the great chemist. It is an affectionate letter."

My Dear Coleridge,

My mind is disturbed, and my body harassed by many labors; yet I cannot suffer you to depart, without endeavoring to express to you some of the unbroken and higher feelings of my spirit, which have you at once for their cause and object.

Years have passed away since we first met; and your presence, and recollections with regard to you, have afforded me continued sources of enjoyment. Some of the better feelings of my nature have been elevated by your converse, and thoughts which you have nursed have been to me an eternal source of consolation.

In whatever part of the world you are, you will often live with me, not as a fleeting idea, but as a recollection possessed of creative energy,—as an imagination winged with fire, inspiring and rejoicing. . . .

May blessings attend you, my dear friend! Do not forget me: we live for different ends, and with different habits and pursuits; but our feelings with regard to each other have, I believe, never altered. They must continue; they can have no natural death; and I trust they can never be destroyed by fortune, chance, or accident.

Thus his sweet, kindly nature was an inspiration to others. He believed in amiability. He said, later, of temper in the marriage state: "Upon points of affection it is only for the parties themselves to form just opinions of what is really necessary to ensure the felicity of the marriage state. Riches appear to me not at all necessary; but competence, I think, is; and after this more depends upon the *temper* of the individual than upon personal or even intellectual circumstances. The finest spirits, the most exquisite wines, the nectars and ambrosias of mod-

ern tables, will be all spoilt by a few drops of bitter extract; and a bad temper has the same effect in life, which is made up, not of great sacrifices or duties, but of little things, in which smiles and kindness, and small obligations given habitually, are what win and preserve the heart and secure comfort."

When Davy was twenty-three, a brilliant opening came to him; came as it did to Cuvier, Newton, and others, through the influence of a friend. Count Rumford had been instrumental in founding the Royal Philosophical Institution for the diffusion of a knowledge of science. Through his works on heat, nitrous oxide, and galvanic electricity, Davy had made the acquaintance of Dr. Hope, the distinguished professor of chemistry in the University of Edinburgh. He recommended Davy to Count Rumford, as fitted for the professorship of chemistry in the Royal Institution, an appointment, Davy wrote to his mother, "as honorable as any scientific appointment in the kingdom, with an income of at least five hundred pounds a year." He had evidently kept the "look towards future greatness" in his heart.

Six weeks after his arrival in London, in the spring of 1801, Davy gave his first lecture, upon the history of galvanism, and the different modes of accumulating galvanic influence. "The sensation created by his first course of lectures at the Institution," says the *Philosophical Magazine*, "and the enthusiastic admiration which they obtained, is at this period hardly to be imagined. Men of the first rank and talent,—the literary and the scientific, the practical and the theoretical,—blue-stockings and women of fashion, the old and the young, all crowded, eagerly crowded, the lecture-room. His youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations and well conducted experiments, ex-

cited universal attention and unbounded applause. Compliments, invitations, and presents were showered upon him in abundance from all quarters; his society was courted by all, and all appeared proud of his acquaintance." He usually wrote his lecture the day before he delivered it, on this day dining in his own room, generally on fish. His manner in speaking was very animated, but natural. He believed in enthusiasm. He said, "Great powers have never been exerted independent of strong feelings. The rapid arrangement of ideas from their various analogies to the equally rapid comparisons of these analogies, with facts uniformly occurring during the progress of discovery, have existed only in those minds where the agency of strong and various motives is perceived—of motives modifying each other, mingling with each other, and producing that *fever of emotion* which is the joy of existence and the consciousness of life."

Coleridge used to say, "I attend Davy's lectures to increase my stock of metaphors."

In the spacious and well supplied laboratory of the Institution, in making his experiments, says his brother, "His zeal amounted to enthusiasm, which he more or less imparted to those around him. With a cheerful voice and countenance, and a hand as ready to manipulate as his mind was quick to contrive, he was indefatigable in his exertions. He was delighted with success, but not discouraged by failure; and he bore failures and accidents in experiments with a patience and forbearance, even when owing to the awkwardness of assistants, which could hardly have been expected from a person of his ardent temperament."

He was very happy in these years of work. Says his brother: "In going to bed, and rising, and sometimes in the dead of night, I used to hear him, in a loud voice,

reciting favorite passages in prose or verse, or declaiming some composition of his own, or humming some angler's song."

He spent his evenings often in society, but wrote to a friend concerning himself: "Be not alarmed, my dear friend, as to the effect of worldly society on my mind. . . . There are in the intellectual being of all men paramount elements,—certain habits and passions that cannot change. I am a lover of nature with an ungratified imagination. I shall continue to search for untasted charms, for hidden beauties. My *real,* my *waking* existence is amongst the objects of scientific research. Common amusements and enjoyments are necessary to me only as dreams to interrupt the flow of thoughts too nearly analogous to enlighten and vivify."

During his vacations he explored most parts of Great Britain, the Hebrides, and Ireland, studying the geological structure, collecting agricultural knowledge, and making sketches. He never hesitated to ask questions, and often the miners and farmers thought they had never seen a person so inquisitive.

In his early years at the Institution he was asked to investigate astringent vegetables in connection with tanning. He entered the work with his usual ardor; visited tan-yards, and made the acquaintance of practical farmers. In 1802 he began to deliver, at the request of the Board of Agriculture, a course of lectures, "On the Connection of Chemistry with Vegetable Physiology." He had made himself acquainted with the different kinds of soil and the various methods of agriculture. For ten years he delivered these lectures at the meetings of the Board. They were published in book form, and translated into almost every European language.

"We feel grateful," said the *Edinburgh Review,* "for his having thus suspended for a time the labors of original

investigation, in order to apply the principles and discoveries of his favorite science to the illustration and improvement of an art which, above all others, ministers to the wants and comforts of man."

He now continued his work with the voltaic pile or battery. If water could be decomposed by it, why not substances heretofore regarded as simple elemental bodies?

In October, 1806, he discovered that potash and soda can be decomposed, with potassium and sodium as resultant bases.

When he saw the minute globules of potassium burst through the crust of potash, and take fire as they entered the atmosphere, he is said to have bounded about the room in ecstatic delight, some time elapsing before he could compose himself sufficiently to go on with his experiment.

He had worked so constantly that he became very ill, and for several weeks his life was despaired of. All London was agitated over the expected death of the young chemist. Bulletins were prepared by the physicians morning, noon, and night, for the scores who came to ask concerning him.

When he had recovered and returned to his work, the Royal Institution provided him with a voltaic battery of six hundred double plates of four inches square, four times as powerful as any that had been constructed, and not long after, one of two thousand plates. Scientific papers were constantly coming from his pen. He soon decomposed boracic acid with the battery. By heating boron in oxygen, it burnt, and was reconverted into boracic acid. In his experiments with muriatic acid gas he found chlorine to be a simple substance, and discovered euchlorine, a compound of chlorine and oxygen.

He had already been made a fellow of the Royal Society at twenty-five, and at twenty-nine one of the secretaries. His lectures were crowded, as ever, by a thousand people.

The Dublin Society now invited him to give courses of lectures in 1810 and 1811, which he did, ticket-holders each paying ten dollars for a course. So difficult was it to gain admission to the lectures that many offered from fifty to a hundred dollars for a course ticket!

He writes these facts to his mother, and adds,

> This is merely for your eye: it may please you to know that your son is not unpopular or useless. Every person here, from the highest to the lowest, shows me every attention and kindness.
>
> I shall come to see you as soon as I can. I hear with infinite delight of your health, and I hope Heaven will continue to preserve and bless a mother who deserves so well of her children.

Trinity College, Dublin, conferred upon him the degree of Doctor of Civil Law. Cuvier said of him: "Davy, not yet thirty-two, in the opinion of all who could judge of such labors, held the first rank among the chemists of this or of any other age." The National Institute of France had awarded him the prize given by Napoleon to the greatest discovery by the means of galvanism.

And yet all this fame and honor had been won by incessant labor. He writes to his mother: "At present, except when I resolve to be idle for health's sake, I devote every moment to labors which I hope will not be wholly ineffectual in benefiting society, and which will not be wholly inglorious for my country hereafter; and the feeling of this is the *reward* which will continue to keep me employed."

His brother John, who had been for three years at the Royal Institution, now went to Edinburgh to study medicine. Davy writes him: "Let no difficulties alarm you, you may be what you please. Trust me, I know what your powers are. Preserve the dignity of your

mind, and the purity of your moral conduct. You set sail with a fair wind on the ocean of life. You have great talents, good feelings, and an unbroken and an uncorrupted spirit. Move straight forward on to moral and intellectual excellence. Let no example induce you to violate decorum,—no ridicule prevent you from guarding against sensuality or vice. Live in such a way that you can always say, the whole world may know what I am doing."

In 1812 Davy was knighted by the Prince Regent. Only thirty-three, and he had come to great renown!

And now an important change was to come into his life. During the preceding year he had become acquainted with Mrs. Appreece, towards whom esteem gradually ripened into affection. When their marriage had been decided upon, he wrote his mother: "I am the happiest of men, in the hope of a union with a woman equally distinguished for virtues, talents, and accomplishments. . . . You, I am sure, will sympathize in my happiness. I believe I should have never married but for this charming woman, whose views and whose tastes coincide with my own, and who is eminently qualified to promote my best efforts and objects in life."

To his brother he writes: "I have been very miserable. The lady whom I love best of any human being has been very ill. She is now well, and I am happy. Mrs. Appreece has consented to marry me: and when the event takes place I shall not envy kings, princes, or potentates. . . . I am going to be married to-morrow; and I have a fair prospect of happiness, with the most amiable and intellectual woman I have ever known." How love idealizes all things, makes a new heaven and a new earth for us! He found in her the two needed qualities for happiness; amiability, without which the life of a man is usually made wretched, and intellectuality, without which

a cultivated man can have little companionship in a wife.

The marriage seems to have been a happy one, for he writes to John later: "Lady D. is a noble creature, and every day adds to my contentment by the powers of her understanding, and her amiable and delightful tones of feeling."

Like the wife of Herschel, she was a wealthy widow, so that after his marriage Davy was enabled to travel, and devote himself wholly to original investigation. He resigned his professorship at the Royal Institution after twelve most useful years.

His "Elements of Chemical Philosophy" was now published, and dedicated to Lady Davy. After a pleasure trip with his wife to the Highlands of Scotland, taking his portable chemical apparatus with him for study, they took a journey to France, Italy, Sicily, and Germany, accompanied by Michael Faraday, afterwards so celebrated, then "his assistant in experiments and writing."

In Paris, where he spent two months, he discovered that iodine is a simple substance, analogous to chlorine. Here he became the intimate friend of many distinguished men. "Humboldt," he said, "was one of the most agreeable men I have ever known; social, modest, full of intelligence, with facilities of every kind; almost *too fluent* in conversation. His travels display his spirit of enterprise. His works are monuments of the variety of his knowledge and resource."

Gay-Lussac he placed "at the head of the living chemists of France."

At Fontainebleau, on the banks of the Rhone, at Mont Blanc, at Vaucluse, Sir Humphry's artistic nature voiced itself in song. He had the poet's temperament, intense, quick, earnest, ardent, aspiring. He loved science, and paid her homage; he loved poetry, and made her his rest and solace and soul-companion.

At Florence he studied the diamond, and found it merely crystallized carbon. At Rome he met Canova, who showed him great attention, and to whom he wrote this sonnet:—

Thou wast a light of brightness in an age
  When Italy was in the night of art:
She was thy country; but the world thy stage,
  On which thou actedst thy creative part.
Blameless thy life—thy manners, playful, mild,
Master in art, but Nature's simplest child.
Phidias of Rome! like him thou stand'st sublime:
And after artists shall essay to climb
To that high temple where thou dwell'st alone,
Amidst the trophies thou from time hast won.
Generous to all, but most to rising merit;
By nobler praise awakening the spirit;
Yet all unconscious of the eternal fame,
The light of glory circling round thy name!

At Milan he met Volta, nearly seventy years old. "His conversation was not brilliant," he said; "his views rather limited, but marking great ingenuity. His manners were perfectly simple."

Around Naples he investigated the phenomena of volcanic eruptions. On his return to London they bought a house in Grosvenor Square. He now published several papers: "Experiments and Observations on the Colors used in Painting by the Ancients"; "Experiments on a Solid Compound of Iodine and Oxygen, and on its Chemical Agencies"; "Action of Acids on the Salts usually called the Hyper-oxymuriates, and on the Gases produced from them."

All his life, besides his ambition to be great, he desired to aid his fellow-men, and in the year 1815 he made a discovery which placed him among the benefactors of the race. In 1812 a terrible explosion of gas had taken

place in a mine, causing the death of nearly a hundred men. The mine was on fire, and the mouth had to be closed, thus bringing sure death to the poor creatures within. Such accidents were so frequent, that a committee of mine proprietors visited the great chemist, to see if science could suggest a remedy.

He at once visited several mines, investigated fire-damp, and found it to be light carburetted hydrogen. After a long and careful series of experiments through several months, he invented the safety-lamp, "a cage of wire gauze, which actually made prisoner the flame of the fire-damp, and in its prison consumed it; and whilst it confined the dangerous explosive flame, it permitted air to pass and light to escape; and though, from the combustion of the fire-damp, the cage might become red hot, yet still it acted the part of a safety-lamp."

Sir Humphry at thirty-seven had immortalized himself. At a public dinner given in his honor at Newcastle, a service of plate worth over twelve thousand dollars was presented to him. After his death this service was given to the Royal Society by his widow, to be sold, and the proceeds applied to the encouragement of science. Emperor Alexander of Russia sent him a splendid silver-gilt vase, with a personal letter; his own sovereign conferred a baronetcy upon him.

When Davy was urged by some friends to take out a patent upon the safety-lamp, and thus make five or ten thousand a year for himself, he said, "I never thought of such a thing: my sole object was to serve the cause of humanity; and if I have succeeded, I am amply rewarded in the gratifying reflection of having done so. I have enough for all my views and purposes; more wealth could not increase either my fame or my happiness. It might undoubtedly enable me to put four horses to my carriage; but what would it avail me to have it

said that Sir Humphry drives his carriage and four?"

He said later of his discovery of the safety-lamp: "I value it more than anything I ever did: it was the result of a great deal of investigation and labor; but if my directions be attended to, it will save the lives of thousands of poor men. I was never more affected than by a written address which I received from the working colliers when I was in the North, thanking me on behalf of themselves and their families for the preservation of their lives."

Sir Humphry used to say: "Whoever wishes to enjoy *peace,* and is gifted with great talents, must labor for posterity. In doing this he enjoys all the pleasures of intellectual labor, and all the desire arising from protracted hope. He feels no envy nor jealousy; his mark is too far distant to be seen by short-sighted malevolence, and therefore it is never aimed at. . . . To raise a chestnut on the mountain, or a palm in the plain, which may afford shade, shelter, and fruit for generations yet unborn, and which, if they have once fixed their roots, require no culture, is better than to raise annual flowers in a garden, which must be watered daily, and in which a cold wind may chill or too ardent a sunshine may dry. . . . The best faculties of man are employed for futurity: speaking is better than acting, writing is better than speaking."

In the spring of 1818 he took his second continental journey with his wife, going through Austria, Germany, and Italy. Commissioned by his king, he made some researches on Herculaneum manuscripts.

On his return to England he was made President of the Royal Society, the position so ably filled by Sir Isaac Newton. Every Saturday evening, poets, artists, and men of science gathered at his receptions. This office he held for seven years, till his declining health compelled his resignation.

In December, 1821, Davy paid a visit to his old home in Penzance, and saw his mother for the last time before her death. A public dinner was given him by his townsmen, which honor he greatly appreciated. He was no longer the poor lad among them. "Every heart, tongue, and eye were as one to do honor to him who had not only rendered the name of their *town* famous and imperishable as science itself, but who had added lustre to the intellectual character of their *country*."

From year to year he continued his experiments. Urged by the commissioners of the navy to remedy the corrosion of copper sheathing on vessels by sea water, he succeeded in rendering the copper negatively electrical by small pieces of tin, zinc, or iron nails. Shells and seaweeds adhered to the noncorroded surface, but the principle of galvanic protection has been applied to various important uses.

In 1824, Sir Humphry took a journey to Norway, Sweden, and Denmark, visiting Berzelius of Sweden, "one of the great ornaments of the age," he said, and Oersted of Denmark, distinguished for his discovery of electro-magnetism.

Towards the close of 1826, when he was only forty-eight, Davy was attacked by paralysis in the right side, having suffered for a year with numbness and pain in his right arm. During his confinement in his room, he corrected the proof sheets of his "Discourses to the Royal Society," published in January, 1827.

In this year, having improved, he went through France, Italy, and Switzerland, hunting and fishing as in his boyhood, and writing "Salmonia, or Days of Fly Fishing," giving descriptions of his journey and his observations on natural history.

In the spring of 1828, he made another journey, to Southern Austria, spending the winter in Italy, and writ-

ing his "Consolation in Travel," which Cuvier called the work of a dying Plato. "I was desirous," he says, "of again passing some time in these scenes, in the hope of re-establishing a broken constitution; and though this hope was a feeble one, yet, at least, I expected to spend a few of the last days of life more tranquilly and more agreeably than in the metropolis of my own country. Nature never deceives us. The rocks, the mountains, the streams, always speak the same language. A shower of snow may hide the verdant woods in spring; a thunder storm may render the blue limpid streams foul and turbulent: but these effects are rare and transient; in a few hours, or at least days, all the sources of beauty are renovated; and Nature affords no continued trains of misfortunes and miseries, such as depend upon the constitution of humanity,—no hopes forever blighted in the bud,—no beings full of life, beauty, and promise, taken from us in the prime of youth. Her fruits are all balmy, bright, and sweet; she affords none of those blighted ones so common in the life of man, and so like the fabled apples of the Dead Sea,—fresh and beautiful to the sight, but, when tasted, full of bitterness and ashes."

From Rome he writes to a friend, a year later, in the spring of 1829:

I am here *wearing away* the winter,—a ruin amongst ruins! . . . I fight against sickness and fate, believing I have still duties to perform, and that even my illness is connected in some way with my being made useful to my fellow-creatures. I have this conviction full on my mind, that intellectual beings spring from the same breath of infinite intelligence, and return to it again, but by different courses. Like rivers born amidst the clouds of heaven, and lost in the deep and eternal ocean,—some in youth, rapid and short-lived torrents; some in manhood, powerful and copious rivers; and some in age, by a winding and slow course, half

lost in their career, and making their exit by many sandy and shallow mouths.

Davy was destined to go back to the Infinite Intelligence in manhood, "a powerful and copious river," however much he "fought against sickness and fate."

On February 23, 1829, he dictated a letter to his brother John: "I am dying from a severe attack of palsy, which has seized the whole body, with the exception of the intellectual organ." He added in his own hand, just legible, "Come as quickly as possible."

When the brother arrived, and was overcome with grief, Sir Humphry received him with a cheerful smile, and bade him not to grieve, but consider the event like a philosopher. He talked more earnestly than ever, and his mind seemed all aglow as with the brilliancy of a setting sun.

At one time he was so near death, that he said "he had gone through the whole process of dying, and that when he awoke he had difficulty in convincing himself that he was in his earthly existence." Reviving somewhat, they journeyed from Italy to Geneva, by slow and easy travel, arriving May 28, 1829. In the night, at half-past two, Sir Humphry was taken very ill, and died almost immediately.

He was buried June 1, in the cemetery outside the walls of the city, having requested to be interred where he died, without any display. The grave is marked by a simple monument erected by his wife. She also founded a prize in his honor, to be given every two years, for the most original and important discovery in chemical science. Only fifty, and his work finished,—no not finished,—for his books, his discoveries, and his character, with its earnest perseverance, its tenderness, its sympathy, its noble aspirations, and its helpfulness to mankind, will live forever!

JOHN JAMES AUDUBON
From an early print

JOHN JAMES AUDUBON

The problem why certain men and women come to eminence, and why others, with apparently as much ability, remain forever in obscurity, is an interesting one to solve. Most persons desire fame; most persons desire wealth; but, for one reason or another, thousands fail to achieve what they desire. They lack either singleness of aim, or adequate perseverance, or determined will, or sound judgment, or, instead of mastering circumstances, they permit circumstances to master them.

It is so easy to be turned aside in life by trivial matters; to be interested in our neighbor's wedding, or our neighbor's profits and losses. Those who oversee the affairs of others rarely oversee their own. Men become very busy over clubs and pastimes; women, over social gatherings and appearance, and die with little accomplished.

Audubon's life furnishes a unique illustration of the result of having a definite purpose, and bending all one's energies to it, till success is attained.

John James Audubon was born at New Orleans, May 4, 1780, in the land of orange groves and magnolias, of birds and sunshine. His grandfather was a poor fisherman of La Vendée, France, with twenty-one children. Unable to support them, they made their way in life as best they could.

When John's father was twelve years old, the fisherman gave him "a shirt, a dress of warm clothing, his blessing, and a cane and sent him out to seek his fortune." He went to Nantes, shipped before the mast;

at twenty-one commanded a vessel, and at twenty-five was owner and captain of a small craft.

Going to St. Domingo, West Indies, he purchased a small estate. Ambitious, as are all persons who succeed, he soon secured an appointment from the Governor of St. Domingo, returned to France, made the acquaintance of influential men, and obtained an appointment in the Imperial navy, with the command of a small vessel of war.

He had what all persons need, true self-appreciation; quite another quality from self-conceit. To believe that we can do things, having kept our characters such that we respect ourselves, is a strong indication that we shall prosper if we make the attempt.

Frequently visiting America in his ship, Audubon purchased land in Louisiana, Virginia, and Pennsylvania. In the former State he married a lady of Spanish extraction, Anne Moynette, both beautiful and wealthy. Of their three sons and one daughter, John James was the youngest son.

The mother was not spared to rear the distinguished naturalist, but perished a few years after his birth, in the insurrection of the colored people of St. Domingo. The father, having purchased a beautiful estate on the Loire, nine miles from Nantes, married a second time, a woman who proved a most indulgent mother to her husband's children. Having none of her own, she humored John in every way, and allowed him to gather moss, curious stones, birds' nests,—indeed, everything which belongs to natural history,—to his heart's content.

On the return of Commodore Audubon to France, finding that the boy was following the bent of his own mind, to the neglect of a solid education, in spite of the tears and entreaties of his wife, he sent him away to school. For a year John was obliged to apply himself closely to

mathematics, taking a ramble to collect specimens whenever it was possible. He studied drawing under the celebrated painter David, and learned to play well on the violin, flute, flageolet, and guitar.

His father had hoped that he would become a soldier under Napoleon, but a lad who could lie on his back under a tree for three weeks, and watch with a telescope the habits of some little gray birds of the color of the bark of the tree, would not care much for the smoke and din of battle. He was therefore sent to America, to look after his father's property.

With a heavy heart the youth said good-bye to France, where he had already sketched two hundred varieties of birds from life. Arriving in New York, he became ill of yellow fever, and was carried to the home of two Quaker ladies in Morristown, whose kindness doubtless saved his life.

When he had recovered, he went to his father's farm at Mill Grove, near the Schuylkill Falls, Pennsylvania, and found, as he said, "a blessed spot." He was free, now, to study natural history; no more mathematics; no more urging to become a soldier. He was delighted with the mill attached to the property, and with the pewees who built their nests near by. "Hunting, fishing, and drawing occupied my every moment," he says; "cares I knew not, and cared nothing for them."

An English gentleman, William Bakewell, descended from the Peverils of Derbyshire, rendered historical by Scott's novel "Peveril of the Peak," owned the adjoining property. Audubon, being French, did not court the acquaintance of the Englishman, indeed avoided him, till one day, as he was following some grouse down the creek in winter, he met Mr. Bakewell.

"I was struck with the kind politeness of his manners," says Audubon, "and found him a most expert marksman,

and entered into conversation. I admired the beauty of his well trained dogs, and finally promised to call upon him and his family. Well do I recollect the morning, and may it please God may I never forget it, when for the first time I entered the Bakewell household. It happened that Mr. Bakewell was from home. I was shown into a parlor, where only one young lady was snugly seated at work, with her back turned towards the fire. She rose on my entrance, offered me a seat, and assured me of the gratification her father would feel on his return; which, she added with a smile, would be in a few minutes, as she would send a servant after him. Other ruddy cheeks made their appearance, but, like spirits gay, vanished from my sight. Talking and working, the young lady who remained made the time pass pleasantly enough, and to me especially so. It was she, my dear Lucy Bakewell, who afterwards became my wife, and the mother of my children."

Mr. Bakewell soon returned, and lunch was provided before leaving on a shooting expedition. "Lucy rose from her seat a second time, and her form, to which I had before paid little attention, seemed radiant with beauty, and my heart and eyes followed her every step. The repast being over, guns and dogs were provided, and as we left I was pleased to believe that Lucy looked upon me as a not very strange animal. Bowing to her, I felt, I knew not why, that I was at least not indifferent to her."

Thus was begun a beautiful affection that ran like a thread of gold through the darkness and light of two struggling lives. The friendship increased as the months went by, for the youth, alone in a strange country, devoted to his foster-mother, needed a woman's love and tenderness to cheer him. Lucy Bakewell taught Audubon English, and he in return gave her drawing lessons.

At Mill Grove the weeks passed pleasantly,—is not the world always beautiful when we love somebody? Audubon says in his journal: "I had no vices; but was thoughtless, pensive, loving, fond of shooting, fishing, and riding, and had a passion for raising all sorts of fowls, which sources of interest and amusement fully occupied my time. . . . I ate no butcher's meat, lived chiefly on fruits, vegetables, and fish, and never drank a glass of spirits or wine until my wedding day. To this I attribute my continual good health, endurance, and an iron constitution."

Here at Mill Grove, while yet a boy, he planned his great work, the "Birds of America," their habits, and a description of them. This one idea dominated Audubon's life. Through poverty and suffering, this one desire was ever before him. It is well to plan early in life what we wish to do, and then *do it*.

One writer has well said of Audubon: "For sixty years or more he followed, with more than religious devotion, a beautiful and devoted pursuit, enlarging its boundaries by his discoveries, and illustrating its objects by his art. In all climates and in all weathers; scorched by burning suns, drenched by piercing rains, frozen by the fiercest colds: now diving fearlessly into the densest forest, now wandering alone over the most savage regions; in perils, in difficulties, and in doubts; with no companion to cheer his way, far from the smiles and applause of society; listening only to the sweet music of birds, or to the sweeter music of his own thoughts, he faithfully kept his path.

"The records of man's life contain few nobler examples of strength of purpose and indefatigable energy. Led on solely by his pure, lofty, kindling enthusiasm, no thirst for wealth, no desire of distinction, no restless ambition of eccentric character, could have induced him to

undergo as many sacrifices, or sustained him under so many trials. Higher principles and worthier motives alone enabled him to meet such discouragements and accomplish such miracles of achievement. He has enlarged and enriched the domains of a pleasing and useful science; he has revealed to us the existence of many species of birds before unknown; he has given us more accurate information of the forms and habits of those that were known; he has corrected the blunders of his predecessors; and he has imparted to the study of natural history the grace and fascination of romance."

At Mill Grove he came near losing his life, on a duck-shooting expedition, by falling through an air hole in the ice. It was three months before he recovered.

At this time "a partner, tutor, and monitor," Da Costa, whom Audubon's father had sent over to superintend a lead-mine enterprise at Mill Grove, refused to give money to the son and objected to his marrying Lucy Bakewell. Resenting the dictation of Da Costa, young Audubon determined to go to France and lay the matter before his father. Da Costa would give him no money, but a letter of credit upon an agent in New York. The youth, nothing daunted, walked all the way to New York, was refused the money by the agent, who hinted that the lad should be seized and shipped to China, borrowed his passage money, went to France, caused the removal of Da Costa, and obtained his father's consent to his marriage. For a year he resided at Nantes, shooting, stuffing birds, and drawing for his beloved book. Then all Frenchmen being liable to conscription under Napoleon, the Commodore obtained leave for his son to return to America.

Once again he was at his dear Mill Grove. In his room "the walls were festooned with all sorts of birds' eggs, carefully blown out and strung on a thread. The

chimney-piece was covered with stuffed squirrels, raccoons, and opossums, and the shelves around were likewise crowded with specimens, among which were fishes, frogs, snakes, lizards and other reptiles."

Lucy's father, concluding that the study of natural history might not bring pecuniary support for his daughter, suggested to Audubon that he obtain some knowledge of commerical pursuits. Love seldom asks about ways and means; too seldom, in fact, for subsequent happiness. Audubon entered the counting-house of Benjamin Bakewell of New York, and soon lost some hundreds of pounds by a bad speculation in indigo. The drying of bird's skins in his room was so disagreeable to his neighbors that a message was sent him, thorough a constable, insisting on his abating the *nuisance!*

Finance did not seem the specialty of the young man, and he returned to Mill Grove.

Dear as the place was to him, he sold it, invested the capital in goods, married Lucy Bakewell, April 8, 1808, when he was twenty-eight years old, and started for the West. They were twelve days in sailing down the Ohio River in a flat-bottomed float, called an ark. He engaged in trade at Louisville, and the young couple were extremely happy. Fortunate it was that they had these few months of comfort, for hardship was soon to test their affection.

The war of 1812 so crippled business that he and his partner decided to go to Hendersonville, while Lucy and her infant son went home to her father for a year. If Mr. Bakewell ever regretted the choice which his daughter had made, she did not, and never failed when days were darkest, to encourage him to write and win renown. When all others bemoaned his lack of business success, and his devotion to a non-paying pursuit, she

alone was his comforter, and was willing to suffer poverty if thus his great work might be done.

There was no success at Hendersonville, and the goods were taken to St. Geneviève. Here the partner married, and Audubon sold his interest to him, purchased a horse, and started across the country to see his wife, who had meantime come back from Pennsylvania to Hendersonville, Ky. In this trip he came near losing his life. He says: "I found myself obliged to cross one of the wild prairies which, in that portion of United States, vary the appearance of the country. The weather was fine, all around me was as fresh and blooming as if it had just issued from the bosom of nature. My knapsack, my gun, and my dog were all I had for baggage and company. But although well moccasined, I moved slowly along, attracted by the brilliancy of the flowers, and the gambols of the fawns around their dams, to all appearance as thoughtless of danger as I felt myself."

After travelling all day, he reached a log cabin. "Presenting myself at the door, I asked the tall figure, which proved to be a woman, if I might take shelter under her roof for the night. Her voice was gruff, and her dress negligently thrown about her. She answered in the affirmative. I walked in, took a wooden stool, and quietly seated myself by the fire. The next object that attracted my notice was a finely formed young Indian, resting his head between his hands, with his elbows on his knees. A long bow rested against the log wall near him, while a quantity of arrows and two or three raccoon skins lay at his feet. He moved not; he apparently breathed not. Accustomed to the habits of the Indians, and knowing that they pay little attention to the approach of civilized strangers, I addressed him in French,—a language not unfrequently partially known to the people of that neighborhood. He raised his head, pointed to

one of his eyes with his finger, and gave me a significant glance with the other; his face was covered with blood.

"The fact was, that an hour before this, as he was in the act of discharging an arrow at a raccoon in the top of a tree, the arrow had split upon the cord, and sprung back with such violence into his right eye as to destroy it forever.

"Feeling hungry, I inquired what sort of fare I might expect. Such a thing as a bed was not to be seen; but many large, untanned buffalo hides lay piled in a corner. I drew a time-piece from my pocket, and told the woman that it was late, and that I was fatigued. She espied my watch, the richness of which seemed to operate on her feelings with electric quickness. She told me there was plenty of venison and jerked buffalo meat, and that on removing the ashes I should find a cake. But my watch had struck her fancy, and her curiosity had to be gratified by an immediate sight of it. I took off the gold chain which secured it around my neck, and presented it to her. She was all ecstasy, spoke of its beauty, asked me its value, and put the chain round her brawny neck, saying how happy the possession of such a watch would make her. Thoughtless, and, as I fancied myself, in so retired a spot, secure, I paid little attention to her talk or her movements. I helped my dog to a good supper of venison, and was not long in satisfying the demands of my own appetite.

"The Indian rose from his seat as if in extreme suffering. He passed and repassed me several times, and once pinched me on the side so violently, that the pain nearly brought forth an exclamation of anger. I looked at him; his eye met mine, but his look was so forbidding that it struck a chill into the more nervous part of my system. He again seated himself, drew his butcher-knife from its greasy scabbard, examined its edge, as I would

do that of a razor suspected dull, replaced it, and, again taking his tomahawk from his back filled the pipe of it with tobacco, and sent me expressive glances whenever our hostess chanced to have her back towards us."

Audubon now perceived his danger. "I asked the woman for my watch, wound it up, and, under the pretence of wishing to see how the weather might probably be on the morrow, took up my gun, and walked out of the cabin. I slipped a ball into each barrel, scraped the edges of my flints, renewed the primings, and, returning to the hut, gave a favorable account of my observations. I took a few bear-skins, made a pallet of them, and, calling my faithful dog to my side, lay down, with my gun close to my body, and in a few minutes was, to all appearance, fast asleep."

Soon two young, stalwart Indians arrived at the cabin, bearing a dead stag on a pole. These were the Indian woman's sons. She and they drank whisky, and then took a large carving-knife to a grindstone, and sharpened it. "I saw her pour the water on the turning machine," says Audubon, "and watched her working away with the dangerous instrument, until the cold sweat covered every part of my body, in despite of my determination to defend myself to the last. Her task finished, she walked to her reeling sons, and said, 'There, that'll soon settle him! Boys, kill you—and then for the watch!'"

Just at this moment the door suddenly opened, and two travellers entered. The mother and her sons were bound, and Audubon's life was saved.

He arrived at last at Hendersonville, and soon went into business with a brother-in-law at New Orleans. He embarked all the fortune at his disposal, and lost it all.

His father had already died, leaving Audubon an estate in France, and seventeen thousand dollars deposited with a merchant in Richmond, Va. The merchant died in-

solvent, and Audubon never received a dollar. He made no effort to possess the property in France, and years afterwards it was transferred to his sister Rosa. He now began to feel anxious about the future. A second son, John, had been born to him, and he must try once more to earn in business. Gathering a few hundred dollars, he purchased some goods in Louisville, and returned to Hendersonville. A former partner joined him, advised erecting a steam mill, which was done. Several men invested capital in the enterprise, and a complete failure resulted. Audubon gave up all the property he possessed to his creditors, and left Hendersonville with his sick wife, his gun, his dog, and his drawings.

They reached Louisville, and were kindly received by a relative. How could he support his family? The outlook was not hopeful. He would try making crayon portraits. He succeeded so well that a farmer came in the middle of the night to request a picture of his mother before she died, and the work was done by candle-light.

Invited to Cincinnati to become curator of the museum, Audubon accepted, and opened a drawing-school in that city. But very little money resulted, and he resolved to seek a new field of labor. Getting letters of recommendation from General, afterwards President, Harrison, and from Henry Clay, he started, October 12, 1820, for New Orleans. Stopping for a time at Natchez, he and a companion found themselves destitute of shoes. Going to a shoemaker, he asked to sketch a crayon portrait of himself and his wife in return for two pairs of boots. The offer was accepted, and Audubon and his friend found themselves again in suitable condition for travelling. How different all this from the former easy life at Mill Grove!

Arriving at New Orleans, what little money he possessed was stolen, he could find no work, and he was

obliged to live on the boat in which he had come thither. He writes in his journal: "Time passed sadly in seeking ineffectually for employment. I was fortunate in making a hit with the portrait of a well-known citizen of New Orleans. I showed it to the public; it made a favorable impression, and I obtained several patrons. A few orders for portraits relieved my necessities, and, continuing my work of painting birds, the time passed more pleasantly."

He was always planning for wider opportunities to study birds for his book. In the midst of his dire poverty, he did not forget this. Now he hoped to join the expedition which surveyed the boundary line of the territory ceded to the United States by Spain, and he says, "Saw nothing but hundreds of new birds in imagination within range of my gun." But this, like other plans, came to naught, for poverty binds with strong cords, and it requires almost superhuman strength to break them.

At last, in the family of Mrs. Perrie, who owned a plantation at Bayou Sara, in Louisiana, he obtained a situation. He was to teach drawing to her daughter for sixty dollars a month, having his afternoons for his work. Her desire was, under the guise of employment, to help the poor naturalist.

After fourteen months since leaving Cincinnati, during which time, he says, "I have finished sixty-two drawings of birds and plants, three quadrupeds, two snakes, fifty portraits of all sorts, and have subsisted by my humble talents, not having had a dollar when I started," he sent for his family to come to him. A house was rented on Dauphine Street, at seventeen dollars a month. Now if they starved, they would starve together. Being asked to join in painting a panorama of the city, he said, "My birds, my beloved birds of America, occupy all my time, and nearly all my thoughts, and I do not wish to see any other perspective than the last specimen of these

drawings." He was now forty-two, and life was none too long, at the best. No wonder he was anxious about his book.

During the first months of 1822, after his family came, there are no records of his life. He was too poor to buy a journal. Mrs. Audubon had found a situation as governess in a family. Audubon was depressed in spirits, and poor health was the result. If some person with wealth had only been wise enough to have helped the man of talent! We build colleges and churches, and this is well; but often neglect the brilliant man or woman near our own door, who might bless the world. Brains do not always win pecuniary success. We sometimes go to extremes in America by advocating self-dependence, and let a refined and sensitive soul break because it cannot breast the world. We forget that on earth we are to be our brother's keeper. Perchance we shall remember it beyond!

Finally Audubon left New Orleans, procuring passage on a boat to Natchez, by a crayon portrait of the captain and his wife. In the family of a Portuguese gentleman in that city, he taught drawing, music, and French, and also drawing in a college nine miles from Natchez, but he was still depressed. "While work flowed in upon me," he says, "the hope of my completing my book upon the birds of America became less clear; and, full of despair, I feared my hopes of becoming known to Europe as a naturalist were destined to be blasted."

To feel within one's breast the aspiration which is God-given, and know that one has genius, and yet be bound hand and foot by circumstances,—what is harder?

Poor Audubon! with his lessening hope of "becoming known to Europe." His wife had come to Natchez and obtained a position as teacher, similar to the one she had held in New Orleans. Poverty had tested their love,

but it had stood the test. Audubon had made a copy of the "Death of Montgomery;" and for this friends raffled, and gave him the proceeds, three hundred dollars, and the picture also.

Mrs. Audubon now made an engagement with a lady at Bayou Sara, to teach her children with her own, and a limited number of pupils. Seeing that his family would now be provided for, "I determined," he says, "to break through all bonds, and pursue my ornithological pursuits. My best friends solemnly regarded me as a madman, and my wife and family alone gave me encouragement. My wife determined that my genius should prevail, and that my final success as an ornithologist should be triumphant."

Blessed faith of woman! Giving a love that knows only self-sacrifice; that braves all, bears all, and finally wins all for its beloved object.

The oldest son, Victor, was placed in the counting-house of a friend at Louisville, and Audubon sought Philadelphia, "as a desperate venture," he says, to see if means could not be obtained to further his work. He took a room, and began to give lessons in drawing. He said plaintively in his journal, "I have now been twenty-five years pursuing my ornithological studies," and yet the book was not written. Fortunately he obtained a letter of introduction to the portrait-painter Sully, "a man after my own heart, and who showed me great kindnesses." He gave Audubon instruction in oil, and would take no pay for it, and the naturalist was "overwhelmed with his goodness." Audubon found another warm-hearted friend,—Edward Harris,—a young ornithologist, who, as he was bidding Audubon good-bye, squeezed a hundred-dollar bill into his hand, saying, "Mr. Audubon, accept this from me; men like you ought not to want for money." "I could only express my gratitude,"

says Audubon, "by insisting on his receiving the drawings of all my French birds, which he did, and I was relieved."

A friend now took him to visit Mill Grove. "As we entered the avenue leading to Mill Grove," he says, "every step brought to my mind the memory of past years, and I was bewildered by the recollections until we reached the door of the house, which had once been the residence of my father as well as myself. . . . After resting a few moments, I abruptly took my hat, and ran wildly towards the woods, to the grotto where I first heard from my wife the acknowledgment that she was not indifferent to me. It had been torn down, and some stones carted away; but, raising my eyes toward heaven, I repeated the promise we had mutually made. We dined at Mill Grove, and as I entered the parlor I stood motionless, for a moment, on the spot where my wife and myself were forever joined."

He then went to New York, and a friend took him to the Lyceum. "My portfolio was examined by the members of the Institute," he says, "among whom I felt awkward and uncomfortable. After living among such people, I feel clouded and depressed; remember that I have done nothing, and fear I may die unknown. I feel I am strange to all but the birds of America. In a few days I shall be in the woods, and quite forgotten." The next day, he writes in his journal: "My spirits low, and I long for the woods again; but the prospect of becoming known prompts me to remain another day."

From this city he journeyed West. "All trembling I reached the Falls of Niagara, and oh, what a scene! My blood shudders still, although I am not a coward, at the grandeur of the Creator's power; and I gazed motionless on this new display of the irresistible force of one of his elements."

At Buffalo, he took a deck-passage on board a schooner bound for Erie, using his buffalo-robe and blanket to sleep on. At Pittsburg, he spent a month scouring the country for birds, and continued his drawings. Arriving at Cincinnati, he says, "I was beset by claims for the payment of articles which years before had been ordered for the Museum, but from which I got no benefit. Without money, or the means of making it, I applied to Messrs. Keating and Bell for the loan of fifteen dollars; but had not the courage to do so until I had walked past their house several times, unable to make up my mind how to ask the favor. I got the loan cheerfully, and took a deck-passage to Louisville. I was allowed to take my meals in the cabin, and at night slept among some shavings I managed to scrape together. The spirit of contentment which I now feel is strange; it borders on the sublime; and, enthusiast or lunatic, as some of my relatives will have me, I am glad to possess such a spirit."

At last he reached Bayou Sara, and saw his wife; "and, holding and kissing her, I was once more happy, and all my toils and trials were forgotten."

Mrs. Audubon had been extremely fortunate. She was earning nearly three thousand dollars a year. This she offered to her husband to help the publication of the book. He was invited to teach dancing, and a class of sixty was soon organized. From this source he received about two thousand dollars. The tide of fortune had turned at last, and he began to prepare for a trip to England. He was forty-six. Life had been indeed a struggle. He had wandered over the country, with scanty food and poor attire, always in debt, but he had drawn his birds; and now the money was actually in his hands, whereby he could, perhaps, "be known in Europe." And Lucy Audubon had made it possible!

He had gained much by his trials. He had learned

what most of us take a life-term to learn, patience; not to speak harshly when others are harsh. He said, "To repay evils with kindness is the religion I was taught to practise, and this will forever be my rule." He had learned that much in life is trivial, that most things are "not matters of life and death;" little worries come to all, and can be borne—the momentous things of life are really few.

April 26, 1826, Audubon sailed for England. Arriving at Liverpool, he was able to arrange for the display of his drawings at the Liverpool Exhibition. The entrance fee was one shilling, and the receipts were from fifteen to twenty dollars a day. Surely fame was coming at last. Lord Stanley spent five hours in examining the collection, and said, "This work is unique, and deserves the patronage of the Crown." He invited Audubon to visit him at his town house in Grosvenor Square. The naturalist made portraits of various friends who were desirous of obtaining specimens of his drawing. From the exhibition of his pictures in Liverpool he realized five hundred dollars.

From this city he went to Manchester, and from thence to Edinburgh. Here he met the naturalist Professor Jameson, who promised to introduce his book to the public in his "Natural History Magazine." Professor Wilson (Christopher North) volunteered to introduce Audubon to Sir Walter Scott. Audubon was asked to sit for his portrait. The Royal Institution offered their rooms for the exhibition of his drawings, and the receipts were from twenty-five to seventy-five dollars a day.

Truly things had changed, since those desolate days in America, when he slept on the deck of a steamboat, because unable to pay for a bed, and could not summon the courage to ask the loan of fifteen dollars.

Invited to dine with the Antiquarian Society, he met

Lord Elgin, who presided, and was obliged to respond to a flattering toast, which made him "feel very faint and chill. I was expected to make a speech," he says, "but could not, and never had tried. Being called on for a reply, I said, 'Gentlemen, my incapacity for words to respond to your flattering notice is hardly exceeded by that of the birds now hanging on the walls of your institution. I am truly obliged to you for your favors, and can only say, God bless you all, and may your society prosper.' I sat down with the perspiration running over me."

Professor Wilson prepared an article upon Audubon and his work for "Blackwood's Magazine." His picture was hung in the Exhibition room. He was made a member of the Wernerian Natural History Society, and of the Royal Society. He was pleased, and said, "So, poor Audubon, if not rich, thou wilt be honored at least, and held in high esteem among men."

No wonder he wrote to his wife: "My success in Edinburgh borders on the miraculous. My book is to be published in numbers, containing four birds in each, the size of life, in a style surpassing anything now existing, at two guineas a number. The engravings are truly beautiful; some of them have been colored, and are now on exhibition. . . . I expect to visit the Duke of Northumberland, who has promised to subscribe for my work. . . . One hundred subscribers for my book will pay all expenses. Some persons are terrified at the sum of one hundred and eighty guineas for a work,"—nearly a thousand dollars,—"but this amount is to be spread over eight years, during which time the volumes will be gradually completed. I am fêted, feasted; elected honorary member of societies, making money by my exhibition and by my paintings. It is Mr. Audubon here, and Mr. Audubon there, and I can only hope that Mr. Audubon will

not be made a conceited fool at last." There was no fear of this. He always remained the modest, earnest, devoted student of nature.

He read before the Natural History Society a paper on the habits of the wild pigeon. He says, "I began that paper on Wednesday, wrote all day, and sat up until half-past three the next morning; and so absorbed was my whole soul and spirit in the work, that I felt as if I were in the woods of America among the pigeons, and my ears were filled with the sound of their rustling wings. After sleeping a few hours, I rose and corrected it. . . . Captain Hall expressed some doubts as to my views respecting the affection and love of pigeons, as if I made it human, and raised the possessors quite above the brutes. I presume the love of the mothers for their young is much the same as the love of woman for her offspring. There is but one kind of love; God is love, and all his creatures derive theirs from his: only it is modified by the different degrees of intelligence in different beings and creatures."

With all this attention, his heart was never callous to suffering. "I was sauntering along the streets," he says, "thinking of the beautiful aspects of nature, meditating on the power of the great Creator, on the beauty and majesty of his works, and on the skill he had given man to study them, when the whole train of my thoughts was suddenly arrested by a ragged, sickly-looking beggar boy. His face told of hunger and hardship, and I gave him a shilling and passed on. But turning again, the child was looking after me, and I beckoned to him to return. Taking him back to my lodgings, I gave him all the garments I had which were worn, added five shillings more in money, gave him my blessing, and sent him away rejoicing, and feeling myself as if God had smiled on me."

There is no sympathy so sweet as that born of ex-

perience. Noble-hearted Audubon! God had indeed "smiled on him." Hereafter he was to walk in the sunlight of that smile. He was to work, of course, for there is no approbation for idleness, but he was to know want no more.

March 17, 1827, he issued the prospectus of his book, which was to cost him over one hundred thousand dollars. Here was courage, but he had been fighting obstacles all his life, and he believed he could succeed. In this he said, "The author has not contented himself, as others have done, with single profile views, but in very many instances has grouped his figures so as to represent the originals at their natural avocations, and has placed them on branches of trees, decorated with foliage, blossoms, and fruits, or amidst plants of numerous species. Some are seen pursuing their prey through the air, searching for food amongst the leaves and herbage, sitting in their nests, or feeding their young; whilst others, of a different nature, swim, wade, or glide in or over their allotted element."

Leaving Edinburgh, Audubon visited Newcastle, Leeds, York, Shrewsbury, and Manchester, securing a few subscribers to his work, at one thousand dollars each. It seemed difficult enough to spend a lifetime in preparing the book, without being obliged to perform the irksome and trying task of selling it; but fame asks Herculean labors of its votaries.

Often he was pained by ill-mannered refusals. How few are like Longfellow, who could say "no" so kindly, that it almost seemed like "yes." Audubon tells, in his journal, of an interview with the great banker Rothschild. On opening the letter brought by the naturalist, the baron said, "This is only a letter of introduction, and I expect from its contents that you are the publisher of some book or other, and need my subscription."

No man can be truly great who knows how to be uncivil!

"Sir," he added, "I never sign my name to any subscription list, but you may send in your work and I will pay for a copy of it. I am busy, I wish you good-morning."

When the book was sent, the baron exclaimed, "What, two hundred pounds for birds! Why, sir, I will give you five pounds, and not a farthing more!" This offer was "declined with thanks," and the book taken back to the publishers.

Very different from Rothschild was Sir Thomas Lawrence, the painter. Overwhelmed with work, he insisted on Audubon's remaining to his simple breakfast of boiled eggs and coffee, called at his rooms, later examined his drawings, and said he would bring a few purchasers, that very day. "In about two hours," says Audubon, "he returned with two gentlemen, to whom he did not introduce me, but who were pleased with my work, and one purchased the 'Otter Caught in a Trap,' for which he gave me twenty pounds sterling, and the other, 'A Group of Common Rabbits,' for fifteen sovereigns. I took the pictures to the carriage which stood at the door, and they departed, leaving me more amazed than I had been by their coming.

"The second visit was much of the same nature, differing, however, chiefly in the number of persons he brought with him, which was three instead of two; each one of whom purchased a picture, at seven, ten, and thirty-five pounds respectively; and, as before, the party and the pictures left together in a splendid carriage with liveried footmen. I longed to know their names, but, as Sir Thomas was silent respecting them, I imitated his reticence in restraining my curiosity, and remained in mute astonishment. . . .

"Without the sale of these pictures, I was a bankrupt, when my work was scarcely begun, and in two days more I should have seen all my hopes of the publication blasted; for Mr. Havell, the engraver, had already called to say that on Saturday I must pay him sixty pounds. I was then not only not worth a penny, but had actually borrowed five pounds a few days before, to purchase materials for my pictures. But these pictures which Sir Thomas sold for me enabled me to pay my borrowed money, and to appear full-handed when Mr. Havell called. Thus I passed the Rubicon!"

Blessings on thee, Sir Thomas Lawrence, carrying out Emerson's divine motto, "Help somebody!"

But Audubon did something more than try to obtain subscribers for his book. He says: "At that time I painted all day, and sold my work during the dusky hours of evening, as I walked through the Strand and other streets where the Jews reigned; popping in and out of Jew shops or any others, and never refusing the offers made me for the pictures I carried fresh from the easel. Startling and surprising as this may seem, it is nevertheless true, and one of the curious events of my most extraordinary life. Let me add here, that I sold seven copies of the 'Entrapped Otter,' in London, Manchester, and Liverpool, besides one copy presented to my friend Mr. Richard Rathbone. In other pictures, also, I have sold from seven to ten copies, merely by changing the course of my rambles; and strange to say, that when, in after years and better times, I called on the different owners to whom I had sold the copies, I never found a single one in their hands."

Painting all day, and selling his pictures at night along the streets of London, all to bring out the "Birds of America"! What a life history is between the leaves of that great work!

Sometimes, in his wanderings, he met poverty that made him "sick of London;" an artist making caricatures, while his wife and six little children begged; but he always gave part of what he had, and went back to his work, more than ever determined to win.

September 1, 1828, Audubon went to Paris, going first to Baron Cuvier. He was busy—who is not that accomplishes anything?—and, while he cordially invited Audubon to dine, went on studying a small lizard. "Great men show politeness in a particular way," says Audubon; "they receive you without much demonstration; a smile suffices to assure you that you are welcome, and keep about their avocations as if you were a member of the family."

Cuvier made a report of Audubon's work to the Academy of Sciences. He said, "It may be described in a few words as the most magnificent monument which has yet been erected to ornithology. . . . Formerly the European naturalists were obliged to make known to America the riches she possessed. . . . If that of Mr. Audubon should be completed, we shall be obliged to acknowledge that America, in magnificence of execution, has surpassed the world."

Audubon also made the acquaintance of Baron Humboldt, Geoffroy Saint-Hilaire, and of Gérard, the painter, who said, "You are the king of ornithological painters. We are all children in France or Europe. Who would have expected such things from the woods of America!"

After two months in Paris, he returned to London, and soon sailed for America. Once on his native soil, he says, "My heart swelled with joy, and all seemed like a pleasant dream at first; but as soon as the reality was fairly impressed on my mind, tears of joy rolled down my cheeks. I clasped my hands, and fell on my knees, and, raising my eyes to heaven, I offered my thanks to

our God, that he had preserved and prospered me in my long absence, and once more permitted me to approach these shores so dear to me, and which hold my heart's best earthly treasures."

He soon reached the Bayou Sara, and "came suddenly on my dear wife: we were both overcome with emotion, which found relief in tears."

He remained with his wife three months, collecting birds and making drawings, and then both sailed together for England.

During his absence he had been made a fellow of the Royal Society of London, much to his delight. Now that his "Birds of America" was coming out, he began earnestly upon a new work, "Ornithological Biography of the Birds of America," containing nearly three thousand pages, and published for him by Mr. Black of Edinburgh. Two publishers refused this famous work, and Audubon published at his own expense. The first volume was finished in three months, and Mrs. Audubon copied it entire to send to America to secure copyright.

Audubon worked untiringly. He wrote all day long, and "so full was my mind of birds and their habits, that in my sleep I continually dreamed of birds."

The "Birds of America" received good reviews in "Blackwood's Magazine," and elsewhere. Audubon said, "I have balanced my accounts with the 'Birds of America,' and the whole business is really wonderful; forty thousand dollars have passed through my hands for the completion of the first volume." Who would believe that a lonely individual, who landed in England without a friend in the whole country, and with only sufficient pecuniary means to travel through it as a visitor, could have accomplished such a task as this publication! Who would believe that once, in London, Audubon had only one sovereign left in his pocket, and did not know of a single

individual to whom he could apply to borrow another, when he was on the verge of failure in the very beginning of his undertaking! And, above all, who would believe that he extricated himself from all his difficulties, not by borrowing money, but by rising at four o'clock in the morning, working hard all day, and disposing of his works at a price which a common laborer would have thought little more than sufficient remuneration for his work!

In the four years required to bring out the work, fifty-six of his subscribers, representing the sum of fifty-six thousand dollars, abandoned him, and he was obliged to leave London, and go into the provinces to supply their places.

September 3, 1831, Audubon returned to America, spent the winter in Eastern Florida, searching for birds and animals, and then some months in Labrador, having sent Victor to England to superintend the engraving of the drawings. In Labrador he collected one hundred and seventy-three skins of birds, and studied carefully the habits of the eiderduck, loons, wild geese, and other birds. Sometimes he was so weary from drawing that "my neck and shoulders, and most of all my fingers, have ached from the fatigue. The fact is, I am growing old too fast, alas! I feel it, and yet work I will, and may God grant me life to see the last plate of my mammoth work finished.

"Labrador is so grandly wild and desolate," he said, "that I am charmed by its wonderful dreariness. . . . And yet how beautiful it is now, when your eye sees the wild bee, moving from one flower to another in search of food, which doubtless is as sweet to her as the essence of the orange and magnolia is to her more favored sister in Louisiana. The little ring-plover rearing its delicate and tender young; the eider-duck swimming man-of-war-

like amid her floating brood, like the guardship of a most valuable convoy; the white-crowned bunting's sonorous note reaching your ears ever and anon; the crowds of sea-birds in search of places wherein to repose or to feed."

On his return from Labrador, he went to Philadelphia, where he was arrested for one of his old partnership debts, and would have been taken to prison except for a friend who kindly offered bail. From here he went to the house of an old friend, Rev. John Bachman of Charleston, S. C., whose two daughters subsequently married the two sons of Audubon, Victor and John. He returned to London, and in 1834 and 1835 published the second and third volumes of the "Ornithological Biography."

In 1836 he came back to America for further research, and received a warm welcome from distinguished men. Daniel Webster and Washington Irving became his earnest friends. The latter said that his work "was highly creditable to the nation," and deserved "national patronage." He dined with Andrew Jackson at the White House. On his return to England he wrote the fourth volume of the "Ornithological Biography," and the fifth the following year.

This year, 1839, he returned to America to spend the rest of his life, purchased a home on the banks of the Hudson in upper New York, which he called "Minnie's Land," the Scotch word for mother, this being the name by which he generally addressed his wife, to whom he left the whole of it at his death.

He was now sixty, but his work was not done. He immediately began to bring out his "Birds of America" in seven octavo volumes, with the figures reduced and lithographed. He exhibited in New York his wonderful collection of drawings, several thousands of birds and animals, all the size of life, by his own hands.

In 1843, taking his son Victor, he started on an expedition to the Yellowstone River, to collect animals and drawings for another great work, the "Quadrupeds of North America." After nearly a year he returned, and began his book. In two years the first volume was ready; but after this he could do no more. The rest of the great work was finished by his sons after his death.

In 1848 the quick, active mind failed. His wife read to him, led him like a child, and at the last fed him. One, at least, had never failed him, since the day when she gave the money she earned to send him to Europe to win renown.

On Thursday morning, January 27, 1851, the eyes dulled for so long once more showed their former lustre and beauty. Audubon did not speak, but he seemed to know that the time had come for the last journey. He reached out his arms, clasped the hands of his wife and children, and died.

Four days later, surrounded by distinguished friends, he was buried in Trinity Church cemetery, where his sons now rest beside him. A singularly guileless, sweet-natured man, who willed to do all this great work when a boy, and achieved it when a man, because he had willed it.

MICHAEL FARADAY

ALMOST every well-educated person knows the name of Faraday, and is familiar with some at least of his more famous discoveries in the electrical realms; but few have ever thought to consider how the man himself achieved greatness. Yet no one ever began with less hopes of a brilliant career, or met with more startling changes of fortune than Michael Faraday as he recognized and grappled with one opportunity after another, until at length he had won for himself in the truest sense the term master experimentalist and physicist, or "philosopher," as he preferred to be called, thinking the latter a broader and more comprehensive term in scientific ethics. The discoveries of magneto-electric induction and of his great "Laws of Electrolysis"—to be found in every text book on chemistry, and dealing with definite electro-chemical decomposition—are the achievements by which Faraday's name lives today; they are the dominating peaks, as it were, in a life of discovery which Tyndall, Faraday's successor and friend, likened to a mountain range in which the general level was high, but which still held here and there a mighty peak standing high above the others. For more than forty years it was the honor and glory of Michael Faraday to hold the scientific name of England aloft among the nations of the world.

And yet, like many another patient worker in various avenues, Faraday's endless researches were often regarded as quite commonplace and of little moment. The story is told, for instance, of Gladstone, great in statesmanship

but sadly lacking in scientific understanding, who watched one of the master's famous experiments terminate in what seemed to him a very uninspiring and matter-of-fact manner, asking: "But, my dear sir, of what use is such a discovery?" "Why," Faraday answered, with droll witticism, "you will soon be able *to tax it*." Again, an old lady seeing Faraday's excitement over the faintest movement of a galvanometer needle, asked innocently what good such an experiment could be. Faraday's reply was the enigmatical answer of Franklin when met with a like ingenuous question: "Madam, of what use is the new-born child?" That same galvanometer deflection opened to Faraday the existence of electro-magnetic induction, and from its further developments have come the electric light, the electric motor, the dynamo, and a host of other inventions which the world in general counts among the comforts and blessings of modern life.

Michael Faraday got little from his ancestry, save his sturdy frame and honest, open-minded disposition. His parents came from "north-country yeoman stock," the paternal grandfather being a journeyman blacksmith by trade. Michael, born on the 22nd of September, 1791, was the third in a family of four children. His mother was almost entirely illiterate, but she made up for her lack in education by neatness, economy, and love, and the home was always as comfortable as circumstances would permit. In the beginning of the nineteenth century, when the boy Michael was but nine years of age, the father's health failed, and the industrial depression of the country united to make the family lot very hard and difficult. According to one of Faraday's biographers, Dr. Bence Jones, "When the price of corn rose above nine pounds a quarter, they were obliged to obtain public relief, and Michael's portion was a loaf, which had to serve him for a week."

The family now lived in some rooms in the upper story of an old coach house in Manchester Square, and the life of Michael was but little removed from that of the average London street boy. "My education," he once wrote, "was of the most ordinary description, consisting of little more than the rudiments of reading, writing, and arithmetic, at a common day-school. My hours out of school were passed at home and in the streets." But somewhere beneath the surface a vital spark of ambition and ability lay dormant, and at length this spirit roused up and sent the lad on a determined hunt for a "job." He found it as errand boy for a prominent bookseller and bookbinder, and so conducted himself that in a year's time he was taken on as an apprentice in the bookbinding department.

Here the boy Michael was brought for the first time into intimate contact with books. He took a deep pleasure in his work, and presently found himself no little interested by the contents of some of the books which came to his hand. Watt's "Improvement of the Mind" gave him a good push in the right direction, and Mrs. Marcet's "Conversations on Chemistry," and the article on electricity in the "Encyclopedia Britannica," which came to the shop to be bound, did the rest. The boy found himself irresistibly drawn toward science. He had a hard task-master and the hours were long, but somehow he managed to scrape together some bits of apparatus, and to find time for a few simple experiments. It was wonderfully fascinating, and young Michael felt that he must have some authentic information and instruction.

But where was this to be found? There were no night schools in those days; he had no money to buy books, even if he knew where such books as he required were to be had. So he stumbled along by himself, until one day in his nineteenth year he chanced to note an ad-

vertisement in a shop window, saying that a Mr. Tatum would give a course of lectures in Natural Philosophy at his home on certain evenings, admission one shilling per lecture. "I *must* go," young Michael decided, but a shilling per lesson was a lot of money for one in his circumstances. He went around to see his brother, who toiling contentedly at the trade of his grandfather and unworried about his own advancement in a rank of which he cared nothing, yet was willing and eager to help his brother to his heart's desire. So between the two the lecture course was financed, and Michael set all his powers to obtaining every possible bit of information from it.

The course soon proved invaluable to the young man. Not only did it open a much wider field of knowledge, but it brought him into touch with people of similar tastes. He formed many desirable friendships, among these that of an artist, who helped him develop his own latent talent so that he was enabled to make very neat illustrations for the notes he made of Mr. Tatum's lectures, and in his spare time bound into four attractive volumes. But, while this new venture was of keenest interest, it unsettled Faraday for his daily toil. Life as a bookbinder no longer thrilled with promise. It was too prosaic. He wanted the excitement of new fields, the call to research work tingled within him, and only the necessity of his bread and butter kept his fingers busy while his mind pondered on how he might take up what interested him so strongly. But a few weeks longer remained of his apprenticeship, so the bondage would not keep him. Was there any place where he might offer himself as an apprentice in science? Alas, he knew of none.

At this juncture, one of the shop's customers who was a member of the Royal Institution, and who had discovered young Faraday's bent, made the lad quite overjoyed by inviting him to attend the last four lectures

of a course which Sir Humphry Davy was just concluding at the Institution. What a treat this was! And how young Michael blessed his kind benefactor. Now, indeed, he knew that he must follow the call of science, and in his helplessness he sat down and wrote to the President of the Royal Society, then waited in feverish hope for an answer which never came. In the meantime, his apprenticeship was concluded, and feeling that he could no longer remain with his hard master, the young bookbinder faced the world almost empty-handed.

What should be done? "Write to Sir Humphry Davy," whispered the voice of Fate, and the young man made haste to obey, sending therewith the notes he had taken of the Davy lectures. A few days later the Davy carriage, which the young man well knew, stopped before his door, and a footman handed in the following note:

SIR,

I am far from displeased with the proof you have given me of your confidence, and which displays great zeal, power of memory, and attention. I am obliged to go out of town, and shall not be settled till the end of January. I will then see you at any time you wish. It would gratify me to be of any service to you. I wish it may be in my power.

I am, sir,

Your obedient humble servant,

H. DAVY.

Well enough, indeed! God grant that some opening might soon be forthcoming, and the prayer was answered almost at once. A situation as an assistant in the laboratory of the Royal Institution became vacant, and Sir Humphry Davy sent for Faraday. "Science is a harsh mistress," he said to the eager lad. "In a pecuniary point of view, she but poorly rewards those who devote

MICHAEL FARADAY

themselves to her service. I doubt not you could do much better financially in the trade you have learned." But young Michael had had enough of the bookbinding business. He gauged it by the example of his narrow-minded master, and quickly made answer that the trade was vicious and selfish, he wished to enter the realms of science, which made its pursuers amiable and liberal. "I must leave the experience of years to set you right in the matter," smiled the great master, the while he privately admired the young man's force of character, and he ended by offering him the former employee's position and salary—twenty-five shillings per week, with quarters at the top of the building.

Young Faraday took on the new duties at once, and quickly showed himself so capable that it was not long until he was helping to perform minor experiments in chemistry, and in addition serving as secretary to Davy. He joined the City Philosophical Society, which had grown from Mr. Tatum's lectures, and besides meeting with them every Wednesday night, he induced a number of the members to form a self-help club which met in his rooms regularly on Saturday nights. In this way the young man not only made rapid strides toward acquiring a scientific education, but he thoroughly entrenched himself with his chief, and when, in October, 1813, Sir Humphry Davy set out on a Continental tour, he took Michael Faraday with him. They were gone two years, and besides seeing the various foreign lands and interesting features of every description, Faraday had the inestimable privilege of meeting many of the great scientific men of Europe, men who afterwards became his close and admiring friends and were of no little help to him in his great life work.

For now Faraday had settled into his niche—the remainder of his scientific life was to be spent at the Royal

Institution. Already his ability had marked him as a coming master, and in 1816 he was asked to lecture before the City Philosophical Society. As a boy taking his first notes, young Faraday had determined that he would one day stand on the lecture platform, and always he had been a close critic of the art of lecturing. How carefully then did he make ready for his first speech! All his matter was faithfully prepared, his experiments tested, and the principles of the elocution lessons he had taken brought to bear upon the problem. It could be no less than a success, and thenceforward the young man gave many addresses, growing each time in power and eloquence, until after serving eleven years in this field he received the crowning triumph—an invitation to lecture before the learned body of the Royal Institution. He was now acclaimed one of the most famous scientific lecturers of his day. "He regarded lecturing as an art," says one of his biographers, "and he brought it to such perfection that no trace of art remained; his manner was absolutely natural, his sympathy with his audience perfect, and his explanations such that the ignorant could understand enough to be interested and the learned could follow him beyond the bounds of their own knowledge."

But great as was Faraday's name as a lecturer, it is by his original discoveries that his name lives. So numerous are these that we can not begin to name them here. "Ohms, ampères, volts, and farads," says Hammond, in his capable "Stories of Scientific Discoveries," "are familiar words in the vocabulary of science; galvanometers and voltameters are familiar objects in every laboratory, sometimes unfortunately treated with the careless contempt that familiarity is said to breed; but they assume a new importance when we realise that all these words are memorials to the work of individual men

—Faraday and his great contemporaries, Galvani, Volta, Ampère, and Ohm."

Faraday said of himself as a boy that he had a lively imagination and that he could as readily believe the Arabian Nights as the Encyclopedia. But he had, also, the essential mind of the philosopher—"he saw life steadily and saw it whole." Working at the very boundaries of knowledge, his mind was never clouded by the shadows, and he was able always, as in the instance of the faint movement of the galvanometer needle, to see stretches of sequence beyond. For this reason, too, he was able to resign the big fees which might have come to him as a commercial consultant and to pursue with keenest enjoyment the poorly paid and solitary lot of the scientific researcher. For to such an one the cash value is ever almost *nil,* but to the public whom he serves it means wealth untold. "I weigh my words," Huxley once proclaimed in a discussion on this point, "when I say that if the nation could purchase a potential Watt, or Davy, or Faraday, at the cost of a hundred thousand pounds down, he would be dirt cheap at the money. It is a mere commonplace and everyday piece of knowledge that what these men did has produced untold millions of wealth in the narrowest economical sense of the word."

But people have been slow in accepting such valuation, and in Faraday's time, as we have already seen, even cultured people failed to take in the significance of his discoveries. They did, however, flock to hear his lectures, and toward the close of his career the Government roused sufficiently to a sense of the value of his work as to vote him three hundred pounds a year. The Queen offered him a house on Hampton Court Green, and there with his faithful wife who had come to him in his thirtieth year, and the beloved niece who had long shared

their home, Faraday whose long life had been a series of adventures looked forward with calm, quiet happiness to the final one. Death found him in his study chair, August 25, 1867. The remains were laid to rest in Highgate Cemetery, with "only a gravestone of the most ordinary kind" to mark the spot, as he had desired.

"Tyndall," Faraday said to this great friend, not long before the end, "the sweetest reward of my work is the sympathy and goodwill which it has caused to flow in upon me from all quarters of the world." And it was even so; for though the old philosopher rarely saw callers, he appreciated all the kindnesses shown him, and it was good to him to know that in a measure the public was beginning to appreciate the great pioneer work he had done in the electrical field. Scientist, lecturer, philosopher, man of opportunities, his name must ever be revered:

> Take him for all in all, he was a man;
> We shall not look upon his like again.

SIR CHARLES LYELL

GALILEO studied and found out the truth that the earth moves around the sun, and died recanting it.

Buffon, the great French naturalist, studied, and ascertained that the earth has been subject to changes which must have required millions of years. He wrote: "The waters of the sea have produced the mountains and valleys of the land—the waters of the heavens, reducing all to a level, will at last deliver the whole land over to the sea, and the sea, successively prevailing over the land, will leave dry new continents like those which we inhabit."

He was at once summoned before the Faculty of Theology in Paris to recant his opinions, saying, "I declare that I had no intention to contradict the text of Scripture; that I believe most firmly all therein related about the creation, both as to order of time and matter of fact; *I abandon everything in my book respecting the formation of the earth,* and, generally, all which may be contrary to the narration of Moses."

A little more than a century later, at Kinnordy, Forfarshire, Scotland, a boy was born, Charles Lyell, who was destined not only to make geology as fascinating to the world as a novel, but to prove more fully and conclusively than any one had previously done that the world is not only six thousand years old, but perhaps six thousand million years old; and that man has lived here not for a few centuries only, but for thousands of centuries. Lyell knew and felt what the Christian world has come to feel, that truth must and will stand, and

that there is no real conflict between science and religion.

Charles Lyell, the eldest of ten children, having two brothers and seven sisters, was born November 14, 1797. He had the early training of an educated and refined father, a man who had devoted himself to the study of botany, and written several works on Dante. The mother was a woman of practical common-sense, and from her, doubtless, Charles inherited that good judgment which characterized all his work and life.

At seven the child was sent to Ringwood, to a school kept by Rev. R. S. Davies. Here, being the youngest, and one of the gentlest, he was spared the roughness too often found in boys' schools. At ten he and his brother Tom were sent to a school in Salisbury, sixteen miles from Bartley Lodge, whither the family had moved from Kinnordy.

Though they missed their favorite sport of hay-making, they enjoyed walks to Old Sarum, a famous camp of Roman times. Here the boys amused themselves by heaping up piles of chalk flints on the opposite ridges, and letting them roll down, and dash against each other like two armies.

The teacher, Dr. Radcliffe, was called "Bluebeard," from having his fourth wife. The boys, however, liked him, because he had the rare merit of being impartial, while they were never tired of annoying another teacher, who had his favorites. Says Lyell of these early days, "Monsieur Borelle's room was within one in which I and eight others slept. One night, when we were very angry with him for having spatted us all round with a ruler, for a noise in the schoolroom which only *one* had made, and no one would confess, we determined to be revenged. We balanced a great weight of heavy volumes on the top of the door, so that no one could open it without their falling on his head. He was caught like a

mouse in a trap, and threw a book in a rage at each boy's head, as they lay shamming sound asleep.

"Another stratagem of mine and young Prescott (son of Sir G. P.) was to tie a string across the room from the legs of two beds, so as to trip him up; from this string others branched off, the ends of which were fixed to the great toes of two sound sleepers, so that when Monsieur drew the lines, they woke, making a great outcry. At last we wearied him out, and he went and slept elsewhere.

"I conclude that there were far too many hours allotted to sleep at this school, for at all others we were glad to sleep after the labors of the day, and got punished for late rising in the morning, and being too late for roll-call. Here, on the contrary, a great many of our best sports were at night, particularly one, which, as very unique and one which lasted all the time I was there, I must describe. It consisted of fighting, either in single combat, or whole rooms against others, with *bolsters*. These were shaken until all the contents were at one end, and then they were kept there by a girth of string or stockings. This made a formidable weapon, the empty end being the handle, and the ball at the other would hit a good blow, or coil round a fellow's leg, and by a jerk pull him up so that he fell backwards. . . . The invading party were always to station a watch at the head of the stairs, to give notice of the approach of 'Bluebeard,' for he was particularly severe against this warfare, though he never succeeded in putting it down. He used to come up with a cane, which, as none were clothed, took dire effect on those caught out of bed. He had a fortunate twist in his left foot, which made his step recognizable at a distance, and his shoe to creak loudly. This offence was high treason, not only because it led to broken heads, and made a horrible row in the night, but because Mrs.

Radcliffe found that it made her *bolsters* wear out most rapidly."

Charles grew ill at Salisbury, and was taken home for three months. "I began," he says, "to get annoyed with *ennui*, which did not improve my health, for I was always most exceedingly miserable if unemployed, though I had an excessive aversion to work unless forced to it. It happened that, a little before this time, my father had for a short time exchanged botany for entomology, a fit which only lasted just long enough to induce him to purchase some books on the latter subject, after which he threw it up; principally, I believe, from a dislike to kill the insects. I did not like this *department* of the subject either. . . .

"Collecting insects was just the sort of desultory occupation which suited me at that time, as it gave sufficient employment to my mind and body, was full of variety, and to see a store continually increasing gratified what in the cant phrase of the phrenologist is termed the 'accumulative propensity.' I soon began to know what was rare, and to appreciate specimens by this test. In the evenings I used to look over 'Donovan's Insects,' a work in which a great number of the British species are well given in colored plates, but which has no scientific merit. This was a royal road of arriving at the names, and required no study, but mere looking at pictures. At first I confined my attention to the Lepidoptera (butterflies, moths, etc.), as the most beautiful, but soon became fond of watching the singular habits of the aquatic insects, and used to sit whole mornings by a pond, feeding them with flies, and catching them if I could.

"I had no companion to share this hobby with me, no one to encourage me in following it up, yet my love for it continued always to increase, and it afforded a most varied source of amusement. . . . Instead of sym-

pathy, I received from almost every one else beyond my home either ridicule, or hints that the pursuits of other boys were more manly. . . . The disrepute in which my hobby was held had a considerable effect upon my character, for I was very sensitive of the good opinions of others, and therefore followed it up almost by stealth; so that, although I never confessed to myself that I was wrong, but always reasoned myself into a belief that the generality of people were too stupid to comprehend the interest of such pursuits; yet, I got too much in the habit of avoiding being seen, as if I was ashamed of what I did."

The temporary ill-health of the schoolboy led to the long hours of observation of nature; these led to a devotion to science, which brought a world-wide fame. Thus, often, that which seems a hindrance in life proves a blessing in the end.

At twelve, Charles was placed in a school where there were seventy boys, with much fagging and fighting. That this roughness was not in accordance with his noble and refined nature is shown by his words, years afterwards: "Whatever some may say or sing of the happy recollections of their school days, I believe the generality, if they told the truth, would not like to have them over again, or would consider them as less happy than those which follow. . . . The recollection of it makes me bless my stars I have not to go through it again.

"My ambition," he says, "during the second half-year was excited by finding myself rising near the top of a class of fifteen boys in which I was; and when miserable, as I often was, with the kicks and cuffs I received, I got into a useful habit of thinking myself happy when I got a high number in the class-paper." Each year he received a prize for speaking, and often prizes for Latin and English original composition.

At seventeen young Lyell entered Exeter College, Oxford. He still devoted many hours to entomology, and took some honors in classics. A book, as is often the case, had already helped to shape his life. He had found and read, in his father's library, Bakewell's "Geology," and was greatly excited over the views there expressed about the antiquity of the earth. Dr. Buckland, Professor of Geology at Oxford, was then at the height of his fame, and Lyell at once attended a course of his lectures and took notes.

College life was having its influence over the youth, for he wrote to his father: "It is the seeing the superiority of others that convinces one how much is to be and must be done to get any fame; and it is this which spurs the emulation, and feeds that 'Atmosphere of Learning,' which Sir Joshua Reynolds admirably describes as 'floating round all public institutions, and which even the idle often breathe in, and then wonder how they came by it.'"

And yet Lyell, like most students, found it a difficult matter to decide what was best for a life-pursuit. His father wished him to study law. In reply, the son says: "As for the confidence and quickness which you were speaking of, as one of the chief requisites of the Bar, I don't know whether intercourse with the world will supply it, but God knows, I have little enough of it now in company."

During his college course, Lyell made a journey with some friends to Staffa, and wrote a poem upon the place, and then, with his parents and his eldest sisters, travelled in France, Switzerland, and Italy. Here, in the midst of art and beautiful scenery, his mind still turned toward science. He thought the collections in comparative anatomy in the Jardin des Plantes, in Paris, would tempt any one to "take up ardently the study of anatomy." In

Cuvier's lecture-room, filled with fossil remains, he found "three glorious relics of a former world, which have added several new genera to the Mammalia."

In the Jura chain he concluded the limestone to be "of a different age from what we passed through before Dijon, for the latter abounded in organic remains, whereas I could not discover one fossil in the Jura. By the roadside I picked up many beautiful petrifactions, which must be forming daily here, where the water is charged plentifully with lime."

"The rock of the Col de Balme," he said, "is a brown, ligneous slate, with some veins of white quartz intersecting it: the appearance is very curious. On the top was the richest carpet of turf I ever saw, spangled with thousands of the deep blue gentian, red trefoil, and other mountain flowers." Nothing said about law, but much about rocks!

At twenty-two Lyell graduated from Oxford. The same year he became a Fellow of the Geological Society of London, and also of the Linnæan Society, and, in accordance with his father's preference, began the study of law in London.

But the way to success is almost never easy. Lyell's eyes became very weak, and he was obliged to desist from reading, and go to Rome with his father. Many a young man, well-to-do, would have given up a profession, preferring a life of leisure. Not so Charles Lyell. On his return he inspected Romney Marsh, an extensive tract of land, formerly covered by the sea, and also the Isle of Wight, and wrote his first scientific paper on the geology of some rivers near his native place in Forfarshire. At twenty-six he was made secretary of the Geological Society. Already such men as Dr. Buckland felt the deepest interest in the enterprising young student, who was devoting himself to original research.

And now he was going to Paris, to perfect himself in French. Dr. Buckland and others gave him letters of introduction to such persons as Humboldt and Cuvier. Fortunate young Lyell! Such men would fan the flame of aspiration to a white heat.

Once in Paris, the stimulus of great minds did its accustomed work—developed and beautified another mind. He attended a levée at Alexander Brongniart's, "who among the English geologists has the highest reputation both for knowledge and agreeable manners of all the French *savants,*" he wrote home to his father. Again he wrote: "My reception at Cuvier's last Saturday will make me feel myself at liberty to attend his *soirées* next week, and they are a great treat. He was very polite, and invited me to attend the Institute on Monday. There he introduced me to several geologists, and put me in an excellent place for hearing. . . .

"Humboldt addressed me, as Duvau had done, with, 'I have the honor of being familiar with your name, as your father has labored with no small success in botany, particularly the cryptogamiæ. . . .' He was not a little interested in hearing me detail the critiques which our geologists have made on his last geological work,—a work which would give him a rank in science if he had never published aught besides. He made me a present of his work, and I was surprised to find how much he has investigated the details of our English strata. . . . He appears to work hard at astronomy, and lives in a garret for the sake of that study. The King of Prussia invited him to adorn his court at the last Congress; thence he went to Vesuvius just after the grand eruption, and brought away much geological information on that head, which he was good enough to communicate to me. He speaks English well. I attend lectures at the Jardin du Roi, on mining, geology, chemistry, and zoölogy, all

gratis! by the first men. . . . I have promised Humboldt to pass the afternoon today in his study. His new edition serves as a famous lesson to me, in the comparison of England and the Continent. There are few heroes who lose so little by being approached as Humboldt."

Who shall estimate the value of such a friendship to a young man! It was a foregone conclusion that Lyell and Agassiz and Liebig, and others, who sought the society of such as Humboldt, and were *willing to work*, would come to greatness.

Cuvier introduced Lyell to Professor Van Breda of Ghent, who gave him letters to all the Dutch universities, —Ghent, Amsterdam, Haarlem, and Leyden.

The next year, 1824, Lyell made a geological tour with M. Constant Prévost, a noted French geologist, from London to Bristol and Land's End, and with Dr. Buckland, in Scotland, where they dined with the far-famed Francis Jeffrey, editor of the "Edinburgh Review." Lyell's eyes still troubled him so that he could scarcely write letters home; but he was laying up a store of knowledge from which the world was to profit in a few years.

In 1825, his eyes having improved, he resumed his law study, and was admitted to the bar. But he could not give up geological work, and published several papers, —one on a dike of serpentine, another on shell marl and fossil fruit, and others on plastic clay in Hampshire and the fresh-water strata of Hants. He had been made a Fellow of the Royal Society at twenty-nine, and was one of the writers in the "Quarterly Review."

The law work went on, but it was easy to see where his heart was. He wrote a friend that he had been "devouring" Lamarck: "That the earth is quite as old as he supposes has long been my creed, and I will try before six months are over to convert the readers of the

'Quarterly' to that heterodox opinion. . . . Buckland has got a letter from India about modern hyænas, whose manners, habitations, diet etc., are everything he could wish, and as much as could be expected had they attended regularly three courses of his lectures."

At thirty-one Lyell had made up his mind "that there is most real independence in that class of society who, possessing moderate means, are engaged in literary and scientific hobbies;" he had given up the law, and planned the book that was to make him famous—"Principles of Geology." He travelled now extensively in Italy and France, studying volcanoes, glaciers, and fossils. At Auvergne, he began work with his dear friend Murchison at six o'clock in the morning, "and neither heat nor fatigue has stopped us an hour," he writes to his parents. "I have really gained strength so much, that I believe that I and my eyes were never in such a condition before; and I am sure that six hours in bed, which is all we allow, and exercise all day long for the body, and geology for the mind, . . . is the best thing that can be invented in this world for my health and happiness."

Eighteen hours of labor daily, and yet he was happy! He had found his life-work now. To a sister he writes about the beetles at Aix. He cannot be laughed out of this study as when a boy. He has been to Parma, to see Professor Guidotti's "finest collection of fossil-shells in Italy, . . . spending three days, from six o'clock in the morning till night, exchanging our respective commodities."

To his sisters he writes all his discoveries in rocks and fossils, with the enthusiasm of a boy.

I rode to the upper Val d'Arno,—a famous day for me,—an old lacustrine deposit, corresponding delightfully with our Angus lakes in all but age and *species* of animals; same genera of shells. They have just extracted the fortieth

skeleton of hippopotamus; have got about twenty elephants, one or two mastodons, a rhinoceros and stags, and oxen out of number. . . . At Rome I found the geology of the city itself exceedingly interesting. The celebrated seven hills, of which you have read, and which in fact are nine, are caused by the Tiber and some tributaries, which have cut open valleys almost entirely through volcanic ejected matter, covered by travertine containing lacustrine shells.

He made the ascent of Etna, and sketched the crater.

Inside the crater, near the lip, were huge masses of ice, between which and the scoriæ and lava of the crater issued hot sulphurous vapors, which I breathed in copiously; and for six hours after I could not, even after eating and drinking, get the horrid taste out of my mouth, for my lungs had got full of it. The wind was so high, that the guide held my hat while I drew; but though the head was cold, my feet got so hot in the cinders, that I was often alarmed that my boots would be burnt.

In 1830, the first volume of "Principles of Geology, being an Attempt to Explain the Former Changes of the Earth's Surface by Reference to Causes now in Operation," was published.

It will not pretend, [he wrote to Murchison], to give even an abstract of all that is known in geology, but it will endeavor to establish the *principles* of *reasoning* in the science; and all my geology will come in as illustration of my views of those principles, and as evidence strengthening the system necessarily arising out of the admission of such principles, which, as you know, are neither more nor less than that *no causes whatever* have from the earliest time to which we can look back, to the present, ever acted, but those *now acting*. . . . I must go to Germany. . . . Their language must be learnt; the places to which their memoirs relate, visited; and then you may see, as I may, to what extent we

may indulge dreams of eminence, at least as original observers.

He, too, like all the other great ones, indulged in "dreams of eminence." Did ever man or woman achieve anything worthy without these dreams?

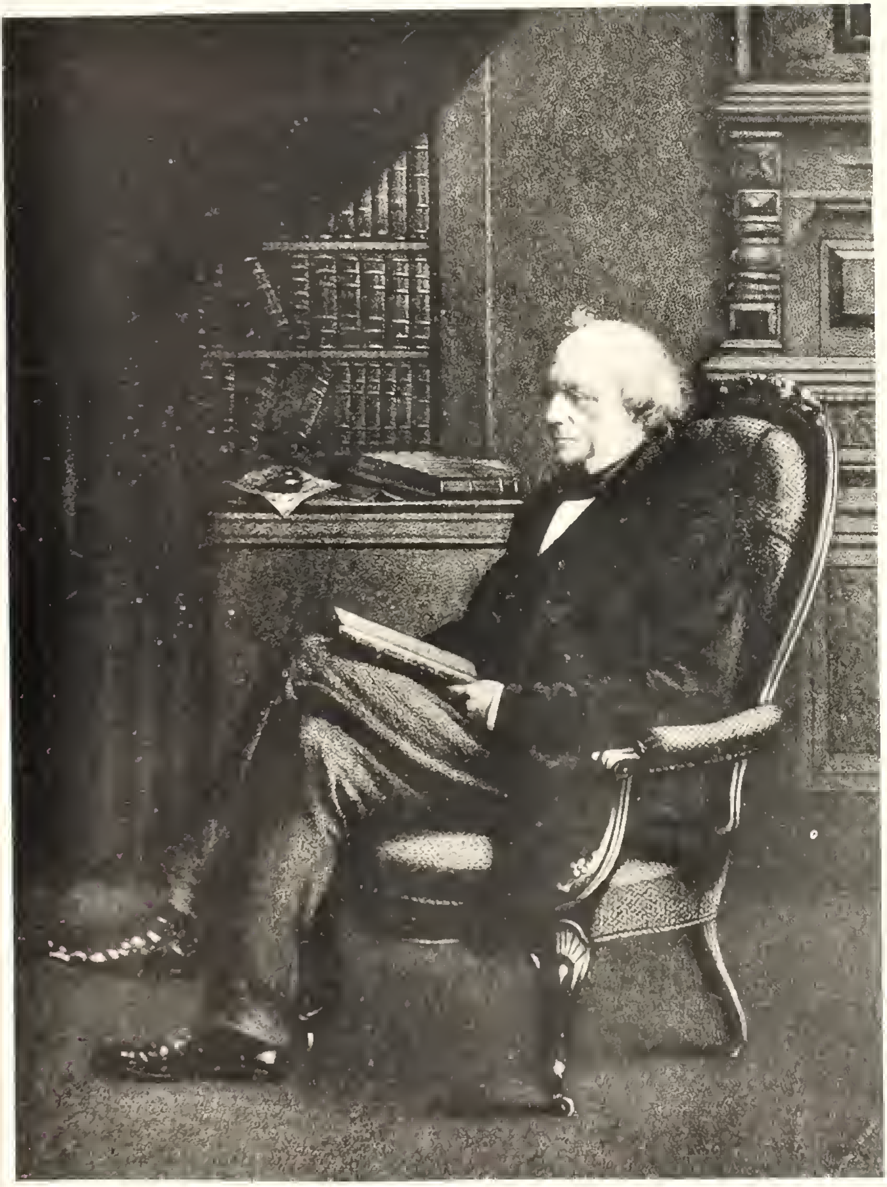
He had worked earnestly upon the "Principles," which showed wonderful research, study, and thought. He said, "The facts which are given in a few sentences require weeks of reading to obtain. . . . By the aid of a good amanuensis, my eyes hold out well."

The sale of the book was large and satisfactory. It was, of course, opposed, from its advanced views as to the age of the world, but Lyell wisely made no reply. He said, "I have sworn to myself that I will not go to the expense of giving time to combat in controversy. It is an interminable work." A great lesson, learned early.

In 1831 he visited Germany. Now he wrote home not only to his family, but to another, who was hereafter to brighten and beautify his life—Mary Horner, the daughter of a prominent scientist. To great personal beauty she added unusual mental ability. Wise man indeed was Charles Lyell to have known, what some fail to know beforehand, that intellect demands intellect for the best companionship.

He wrote to her:

I am sure you will work at it [the German language] with more zeal if you believe you can help me by it, as I labor with greater spirit, now that I regard myself as employed for you as well as for myself. Not that I am at all sanguine about the pecuniary profits that I shall ever reap, but I feel that if I could have fair play for the next ten years, I could gain a reputation that would make a moderate income for the latter part of my life, yield me a command of society, and a respect that would entitle me to rest a little



SIR CHARLES LYELL

on my oars, and enable me to help somewhat those I love. . . . As to geology having *half* of my heart, I hope I shall be able to give my *whole* soul to it, with that enthusiasm by which alone any advance can be made in any science, or, indeed, in any profession.

In 1832 Lyell was made professor of geology in King's College, London, which position he resigned later, because he wished "the power of commanding *time* to increase his knowledge and fame." This year also, July 12, when he was thirty-five, he was married to Mary Horner, and made a tour up the valley of the Rhine.

The earnest life was now more earnest and busy than ever. He said, "I am never so happy as when, at the end of a week, I feel I have employed every day in a manner that will tell to the rest of my life." Would that all of us could live after so noble a plan!

"Unless I can feel that I am working to some decided end, such as that of fame, money, or partly both, I cannot be quite happy, or cannot feel a stimulus to that strenuous application without which I should not remain content." He had learned what "strenuous application" means, and knew that there is no success without it. When congratulated by his friends "in not looking older for his hard work," he said, "The way to do much and not grow old is, to be moderate in not going out, to work a few hours, or half-hours, at a time, . . . and to go to bed at eleven o'clock." He would not accept many invitations socially. "A man should have some severity of character, and be able to refuse invitations, etc.," he said. "The fact is, that to become great in science, a man must be nearly as devoted as a lawyer, and must have more than mere talent. . . . I think I never do so much as when I have fought a battle not to go out." Those who have written books will appreciate this statement, and recall the many days when they have closed the shut-

ters and worked, though they longed to be out-of-doors in the sunlight.

In 1833, the year after his marriage, he gave by invitation a course of seven lectures before the Royal Institution, a high honor. In 1834, he passed several months in Sweden, and wrote back to his "dearest Mary," —"I have been ten hours without a word with my love, but thinking of her more than half the time, and comforting myself that she is less alone than I am." . . . He kept a journal for her of his daily work.

"It is now twenty-five days that we have been separated, and I have often thought of what you said, that the active occupation in which I should constantly be engaged would give me a great advantage over you. I trust, however, that you also have been actively employed. At leisure moments I have done some things towards planning my next volume. It will be necessary for us to have a work together at fossils at Kinnordy, first and then in town, and then in Paris." Thus fully had the young wife entered into his studies.

In 1835, having received the gold medal of the Royal Society, for his "Principles of Geology,"—now in its fourth edition, which Sir John Herschel said he had read three times,—he was elected president of the Geological Society of London, and made extensive researches in Switzerland, Germany, and Scotland.

In 1841, already famous as well as beloved, Lyell was invited to give twelve lectures before the Lowell Institute, in Boston. He and his wife spent thirteen months in the United States, studying the country geologically; its social life, its politics, and our benevolent and educational institutions. Between two and three thousand persons came, both morning and evening, to listen to the distinguished scholar, who had travelled almost the world over to study his beloved science.

Close friendships were formed with some of our most prominent men, like Prescott and Ticknor. Lyell visited the great lakes, and compared the supposed ancient boundaries of Lake Ontario, when it was one hundred and fifty feet higher, with its present shore. He made a careful study of Niagara Falls, which cuts its deep gorge toward Lake Ontario, for seven miles, and estimated that it wore away a foot a year. If so, he argued that at least thirty-five thousand years have passed since the river began to cut its passage between the high rocky walls. "What would I give," said Lyell, "for a daguerreotype of the scene as it was four thousand, and again forty thousand years ago! Even four centuries would have been very important." Authorities differ as to the rate of the recession of the falls. Some estimate an inch instead of a foot yearly, requiring a period of more than four hundred thousand years.

In 1845, Lyell published his "Travels in North America, with Geological Observations," and in September of the same year, returned again to our country, spending nine months in travel and study, bringing out later, in 1849, his "Second Visit to the United States of North America."

Already his "Elements of Geology" had appeared, which went through several editions. A seventh edition of the "Principles" had been published. He had also been knighted by the Queen, for his rare scholarship. Honored at home and abroad, working ardently and earnestly, often with failing sight, he had already won for himself the eminence of which he had dared to dream years before.

Of course he was welcomed at all great gatherings. Macaulay and Hallam, Milmore and Mrs. Somerville, Rogers, and scores of others were often at his home.

In 1851, he was appointed one of the Royal Com-

missioners for the first Great Exhibition held in Hyde Park, London, and a year later gave a second course of lectures at the Lowell Institute, Boston. So kindly and cordially had he written concerning us and our country, that he received the heartiest welcome. He had carried out in his life what he wrote to beautiful Mary Horner, twenty years before: "I hope we shall both of us contrive to cultivate a disposition—which David Hume said was better than a fortune of one thousand pounds a year —to look on the bright side of things. I think I shall, and I believe you will." The sweet-natured and great-minded man had looked on the bright side of America, and seen the good rather than the evil. He believed in our future. When Prescott died, to whom he was devotedly attached, he said: "From such a soil and in such an atmosphere, great literary men must continue to spring up.

All through our Civil War, he had known and loved us so well, that he was, like John Bright, our constant advocate. He deprecated the course of some of the English newspapers. "The integrity of the empire," he said, "and the non-extension and for the last two years the extinction of slavery constitute to my mind better grounds for a protracted struggle than those for which any war in our time, perhaps in all history, has been waged. . . . I am in hopes that the struggle in America will rid the country in the course of twenty years of that great curse to the whites, slave labor, and, if so, it may be worth all it will cost in blood and treasure. . . ."

"Had the States been dismembered, there would have been endless wars, more activity than ever in breeding slaves in America, and a renewal of the African slave-trade, and the future course of civilization retarded in that continent in a degree which would not, in my judgment, be counterbalanced by any adequate advantage which

Europe would gain by the United States becoming relatively less strong. . . . I believe that if a small number of our statesmen had seen what I had seen of America, they would not have allowed their wishes for dismemberment to have biassed their judgment of the issue so much."

In 1853, at the request of his government, he came to New York, as one of the commissioners to the International Exhibition. Of course, now, wherever he travelled, either in Europe or America, he met the distinguished, and was honored by them. He was the friend of Berzelius, the noted chemist of Sweden, and of the great Liebig of Germany. Professor Bunsen of Heidelberg said, that all his taste for geology had been derived from Lyell's books.

During the next few years, he was much in Holland, France, and Germany, preparing for the publication of another great work in 1863, the "Antiquity of Man." He had made a careful study of the ancient Swiss Lake-dwellings, erected on piles in the midst of the water, connected with the land by bridges. On Lake Neuchâtel it is estimated that there were more than forty such circular houses. At Wangen, near Stein, on Lake Constance, it is believed forty thousand piles were used. Some five thousand objects have been found, comprising flax, not woven, but plaited; carbonized wheat, and the bones of the dog, ox, sheep, and goat. The arrow-heads, hatchets, and the like, belong to the Stone Age, which geologists place, at the least, ten thousand years ago. At Zurich one human skull was found belonging to this early Stone Age. No traveller should pass through Zurich without seeing these memorials of a people who lived in the dawn of civilization, when the world was being made ready for the more perfect man.

Lyell had studied also the Danish "kitchen-middens,"

familiar to those who have been carefully over the museums at Copenhagen. These shell-mounds, the refuse heaps of this ancient race, are sometimes one thousand feet long and two hundred wide. As far back as the time of the Romans the Danish Isles were covered with magnificent beech forests. In the Bronze Age there were no beech trees, but oaks. In the Stone Age the Scotch fir prevailed, and thousands of years must have elapsed while these giant forests succeeded each other.

The delta and alluvial plain of the Mississippi Lyell found to consist of sediment covering an area of thirty thousand square miles, several hundred feet deep. Taking the amount deposited annually, it would require from fifty to one hundred thousand years to produce the present deposits.

Lyell showed that the Alps, Andes, and Himalaya Mountains were all elaborated under water. "The Alps have acquired four thousand, and even, in some places, more than ten thousand feet of their present altitude since the commencement of the Eocene (dawn of recent) period. . . . It is not too much to say that every spot which is now dry land has been sea at some former period, and every part of the space now covered by the deepest ocean has been land. The present distribution of land and water encourages us to believe that almost every conceivable transformation in the external form of the earth's crust may have been gone through. In one epoch the land may have been chiefly equatorial; in another, for the most part polar and circumpolar."

Lyell showed also the great age of the world by the changes which have taken place in climate. In Greenland are a multitude of fossil plants, which show that it formerly enjoyed a mild and genial climate. Fossil tulip and walnut trees have been found within the Arctic circle.

"On the North American continent, between the Arctic

circle and the forty-second parallel of latitude," said Lyell, "we meet with signs of ice-action on a scale as grand, if not grander than in Europe." The drift covered from the Atlantic border of New England and Labrador westward to Dakota and Lake Winnipeg, and farther north, across the continent. Some stones in this bed of ice were thirty feet square, weighing over four million pounds. Some boulders from the Alps, weighing three thousand tons each, are now found on the Juras. "It must, I think," said Lyell, "be conceded that the period required for the coming-on of the greatest cold, and for its duration when most intense, and the oscillations to which it was subject, as well as the retreat of the glaciers and the 'great thaw,' or disappearance of snow, from many mountain-chains where the snow was once perpetual, required not tens, but hundreds, of thousands of years."

No wonder Lyell became fascinated with the history of the changes of this planet, and the life of man before historic times. A great book seemed open to him, and he studied it by night and by day: the Archæan Time—no life; Paleozoic Time, including the Silurian Age, with its shells and trilobites; the Devonian, with its fishes; Carboniferous, with its coal plants; Mesozoic Time, including the Reptilian Age with its reptiles; Cenozoic Time, including the Mammalian or Tertiary, with its mammals, and Quaternary, or age of man. Paleozoic means "ancient life;" Mesozoic, "middle life;" Cenozoic, "recent life."

Lyell divided the Tertiary strata into three groups: Eocene, recent dawn; Miocene, less recent; Pliocene, more recent. In the Eocene Age Great Britain was subtropical, and, in North America, Vermont was like North Carolina in temperature. Then came the Glacial Period, with ice probably five thousand feet thick over New

England. Then the Champlain Period, with its floods, continents depressed, and climate warm, followed in Europe by a second Glacial Period.

The "Antiquity of Man" had an extensive sale. Honors were now showered upon Sir Charles Lyell. He was offered the Presidency of the Royal Society, and a seat in Parliament for the University of London, but declined both. Oxford University had already conferred upon him the degree of D. C. L., and the Institute of France had made him corresponding member. By request of the queen, he visited her at Osborne, she having made him a baronet. Germany conferred upon him the Order of Merit, given also to Humboldt, and the London Royal Society, its highest honor, the Copley gold medal.

In the spring of 1873, his "dearest Mary" died, leaving him heart-broken. She was mourned in America as well as Europe. The "Boston Advertiser" said, "Strength and sweetness were hers, both in no common measure. . . . She became to her husband not merely the truest of friends, and the most affectionate and sympathizing of companions, but a very efficient helper. She was frank, generous, and true; her moral instincts were high and pure; she was faithful and firm in friendship. . . . This woman so widely informed, so true, so strong, so brave, seemed all compact of softness, sweetness, and gentleness; a very flower that had done no more than drink the sunshine and the dew. In her smile, her greeting, the tones of her voice, there was a charm which cannot be described, but which all who knew her have felt and will recall. . . . During the war there was not a woman or a man in England that stood by the Union and the government more ardently and fearlessly than she." Lady Lyell was an efficient linguist, and a woman of unusual mental power. The success of her husband was in part the result of her lovely character. Had she sought

society while he needed quiet for his work, had she been fond of dress when their income was limited and necessarily used in his extensive travels, his life might have been a failure. They had what Tolstoï well calls "the friendship of the soul; identity of sentiment and similarity of ideal." Too often in this world persons marry "opposites," and walk, alas! in opposite directions all their lives.

Lyell now worked on, for he said he must carry out what he had planned with *her*. In 1872 the eleventh edition of the "Principles" appeared. Lyell, though formerly an opponent, had become convinced of the truth of evolution, advocated by his devoted friend Darwin, and was proud of our own distinguished botanist Asa Gray, whose articles, he said, "were the ablest, and, on the whole, grappling with the subject, both as a naturalist and metaphysician, better than any one else on either side of the Atlantic."

Lyell believed ever in "an infinite and eternal Being." He said, "In whatever direction we pursue our researches, whether in time or space, we discover everywhere the clear proofs of a Creative intelligence, and of his foresight, wisdom, and power."

He used to quote Professor Agassiz, who said, "Whenever a new and startling fact is brought to light in science, people first say, 'It is not true,' then that 'it is contrary to religion,' and lastly that 'everybody knew it before.'"

For the last ten years of his life, unable to use his eyes to any great extent, Lyell had the assistance, as secretary, of the able author of the "Fairy Land of Science," Miss Arabella Buckley, later Mrs. Fisher. And yet he accomplished more than most people with the best of eyes.

Two years after his wife's death, while at work on the twelfth edition of the "Principles," the end came,

February 22, 1875. He was buried in Westminster Abbey, beside his friend Sir John Herschel,—The Duke of Argyll, Professor Huxley, and other noted men acting as pall-bearers. Said the Dean of Westminster, in the funeral sermon preached in the Abbey, "He followed truth with a zeal as sanctified as ever fired the soul of a missionary, and with a humility as child-like as ever subdued the mind of a simple scholar. . . . From early youth to extreme old age, it was to him a solemn religious duty to be incessantly learning, constantly growing, fearlessly correcting his own mistakes, always ready to receive and reproduce from others that which he had not in himself. Science and religion for him not only were not divorced, but were one and indivisible." Truly said Tyndall, Huxley, and others, "For the last twenty-five years he has been the most prominent geologist in the world; equally eminent for the extent of his labors and the breadth of his philosophical views."

To the last Sir Charles Lyell kept his affectionate, tender heart, with gentle and kindly manners. He was fair to his opponents, and appreciative of all talent. He took time to help others. He urged the name of Agassiz as the lecturer before the Lowell Institute, Boston, and we all know the grand results of his coming. Those who have no time to help others usually fail of help when their own time of need comes. Lyell was singularly free from vanity, egotism, or jealousy. He loved nature devotedly, the grandeur of the sea especially impressing him; he never tired of wandering alone beside it. He had great steadiness of purpose, and calm judgment. His perseverance was untiring; his power of work remarkable; his sympathy boundless. He was never narrow or opinionated. He died as he had lived; honored the world over for his amazing knowledge, and loved for his unselfish, earnest, and beautiful character.

LOUIS AGASSIZ

In the midst of as beautiful scenery as one finds on earth, snow-white Alps, blue lakes, great fields of purple crocus, and picturesque homes, Jean Louis Rodolphe Agassiz was born at Motier, on Lake Morat, Switzerland, May 28, 1807.

His father, a clergyman, descended from a long line of clergymen, was a gentle but efficient man, universally esteemed. His mother, Rose Mayor, the daughter of a physician on the shore of Lake Neuchâtel, was a woman of strong character and most tender affection. She had buried her first four children; therefore Louis was cared for with unusual solicitude.

Until he was ten years old, he was taught by his parents, and allowed to develop his natural tastes. Possibly his sweetness of disposition resulted, in part, from the wise training of the father and mother. Doubtless as many children are spoiled by undue thwarting and irritating as by over-indulgence. Though Louis met almost unsurmountable obstacles later in life, he was able to rejoice, having enjoyed a sunny childhood. Such a childhood we can give to our children but once.

In a great stone basin back of the parsonage, the boy made his first aquarium. There he gathered fishes, frogs, tadpoles, indeed, everything which he could obtain from Lake Morat. In the house he had pet birds, hares, rabbits, field-mice, with their families, all cared for as though they were royal visitors.

He was skilful as a carpenter and boot-maker. When the village cobbler came to the house, two or three times

a year, to make shoes for the family, the lad was quick to imitate him, and made well-fitting shoes for his sister's dolls.

Elizabeth Cary Agassiz, in her fascinating life of her husband, tells this incident of his boyhood: "Though fond of quiet, indoor occupation, he was an active, daring boy. One winter day, when about seven years of age, he was skating with his little brother Auguste, two years younger than himself, and a number of other boys, near the shore of the lake. They were talking of a great fair held that day at the town of Morat, on the opposite side of the lake, to which M. Agassiz had gone in the morning, not crossing upon the ice, however, but driving around the shore.

"The temptation was too strong for Louis, and he proposed to Auguste that they should skate across, join their father at the fair, and come home with him in the afternoon. They started accordingly. The other boys remained on their skating ground till twelve o'clock, the usual dinner hour, when they returned to the village. Mme. Agassiz was watching for her boys, thinking them rather late, and, on inquiring for them among the troop of urchins coming down the village street, she learned on what errand they had gone. Her anxiety may be imagined. The lake was not less than two miles across, and she was by no means sure that the ice was safe.

"She hurried to an upper window with a spy-glass, to see if she could descry them anywhere. At the moment she caught sight of them, already far on their journey, Louis had laid himself down across a fissure in the ice, thus making a bridge for his little brother, who was creeping over his back. Their mother directed a workman, an excellent skater, to follow them as swiftly as possible. He overtook them just as they had gained the shore, but it did not occur to him that they could

return otherwise than they had come, and he skated back with them across the lake. Weary, hungry, and disappointed, the boys reached the house without having seen the fair or enjoyed the drive home with their father in the afternoon."

At ten, Louis was sent to a school for boys at Bienne, where, though the children studied nine hours a day, the time was wisely divided between work and play, so that they were kept well and happy. The lad always remembered affectionately his teacher at this school, Mr. Rickly. When the vacations came, Louis and Auguste walked twenty miles home to Motier, and did not find the journey long or tedious.

At fourteen, Louis left Bienne, having finished his education, as he supposed, prior to entering the business house of his uncle, François Mayor, at Neuchâtel. That his young mind turned longingly towards a different future, may be seen from his desires written at this time on a sheet of foolscap.

"I wish to advance in the sciences, and for that I need D'Anville, Ritter, an Italian dictionary, a Strabo in Greek, Mannert and Thiersch; and also the works of Malte-Brun and Seyfert. I have resolved, as far as I am allowed to do so, to become a man of letters, and at present I can go no further: first, in ancient geography, for I already know all my note-books, and I have only such books as Mr. Rickly can lend me; I must have D'Anville or Mannert; second, in modern geography also, I have only such books as Mr. Rickly can lend me, and the Osterwold geography, which does not accord with the new divisions; I must have Ritter or Malte-Brun; third, for Greek I need a new grammar, and I shall choose Thiersch; fourth, I have no Italian dictionary, except one lent me by Mr. Moltz; I must have one; fifth, for Latin I need a larger grammar than the one I have,

and I should like Seyfert; sixth, Mr. Rickly tells me that, as I have a taste for geography, he will give me a lesson in Greek (*gratis*) in which we would translate Strabo, provided I can find one. For all this I ought to have about twelve louis. I should like to stay at Bienne till the month of July, and afterward serve my apprenticeship in commerce at Neuchâtel for a year and a half. Then I should like to pass four years at a university in Germany, and finally finish my studies at Paris, where I would stay about five years. Then, at the age of twenty-five, I could begin to write."

At this early age, then, he was thinking of being an author!

He begged his parents to defer the business project for two years, that he might study at the College of Lausanne. They were willing and glad to please their boy; but they knew from experience the ills of poverty, and they hoped to save him from it by a wise choice of a life-work.

They gratified him, however, and he went to Lausanne. His uncle, Dr. Mathias Mayor, a physician of Lausanne, seeing that the boy was deeply interested in anatomy, advised that he should study medicine; so this was decided upon, as being more in accord with Louis' tastes than business.

As poor Vincenzio Galileo found it a difficult matter to make a wool merchant or a doctor out of a boy destined to be a man of science, so did the father of Louis Agassiz.

At seventeen, Louis left Lausanne for the medical school at Zurich. Here he became the friend as well as pupil of Professor Schinz, who held the chair of Natural History and Physiology. He gave young Agassiz a key to his private library, and also to his collection of birds; of course, the love for natural history grew stronger. Both boys, for Auguste had come to

Zurich with his brother, were too poor to buy books even when they cost but a dollar a volume. The Swiss minister was saving to the uttermost to pay for board and decent clothes for his sons, to say nothing of books. Therefore the use of Schinz's library was a great favor.

Said Agassiz in after years, "My inability to buy books was, perhaps, not so great a misfortune as it seemed to me; at least, it saved me from too great dependence on written authority. I spent all my time in dissecting animals and in studying human anatomy, not forgetting my favorite amusements of fishing and collecting. I was always surrounded with pets, and had at this time some forty birds flying about my study, with no other home than a large pine-tree in the corner. I still remember my grief when a visitor, entering suddenly, caught one of my little favorites between the floor and the door, and he was killed before I could extricate him. Professor Schinz's private collection of birds was my daily resort, and I then described every bird it contained, as I could not afford to buy even a text-book of ornithology.

"I also copied with my own hand, having no means of purchasing the work, two volumes of Lamarck's 'Animaux sans Vertèbres,' and my dear brother copied another half-volume for me. I finally learned that the study of the things themselves was far more attractive than the books I so much coveted, and when, at last, large libraries became accessible to me, I usually contented myself with turning over the leaves of the volumes on natural history, looking at the illustrations, and recording the titles of the works, that I might readily consult them for identification of such objects as I should have an opportunity of examining in nature."

The boys remained two years at Zurich. One vacation, as they were walking home, the family having moved

from Motier to Orbe, they were overtaken by a gentleman who asked them to ride, shared his lunch with them, and took them to their own door. Some days afterward he wrote to M. Agassiz that he had been so impressed by his son Louis that he wished to adopt him and provide for him through life.

This request caused great commotion in the little home, for the writer of the letter was a man of wealth in Geneva, but after careful consideration, both parents and son declined the offer, preferring to struggle with poverty rather than bear separation.

At the end of the two years in Zurich, Auguste went to the commercial house of his uncle at Neuchâtel, and Louis to the University of Heidelberg, taking letters of introduction from Professor Schinz and others. Professor Tiedemann, the chancellor, had studied with Schinz; therefore, Agassiz received a warm welcome, and an offer of books from his library.

The young student worked earnestly. He wrote to his father: "Every morning I rise at six o'clock, dress and breakfast. At seven I go to my lectures given during the morning. . . . If, in the interval, I have a free hour, as sometimes happens from ten to eleven, I occupy it in making anatomical preparations. . . . From twelve to one I practise fencing. We dine at about one o'clock, after which I walk till two, when I return to the house and to my studies till five o'clock. From five to six we have a lecture from the renowned Tiedemann. After that, I either take a bath in the Neckar, or another walk. From eight to nine I resume my special work, and then, according to my inclination, go to the Swiss Club, or, if I am tired, to bed. I have my evening service and talk silently with you, believing that at that hour you also do not forget your Louis, who thinks always of you."

LOUIS AGASSIZ

At Heidelberg, like Humboldt, Agassiz needed a congenial friend, and found one in Alexander Braun, of Carlsruhe, an ardent lover of botany, afterward Director of the Botanical Gardens in Berlin. He wrote to his parents concerning Agassiz, "a rare comet on the Heidelberg horizon. . . . Not only do we collect and learn to observe all manner of things, but we have also an opportunity of exchanging our views on scientific matters in general. I learn a great deal from him, for he is much more at home in zoölogy than I am. He is familiar with almost all the known mammalia, recognizes the birds from far off by their song, and can give a name to every fish in the water.

"In the morning we often stroll together through the fish market, where he explains to me all the different species. He is going to teach me how to stuff fishes, and then we intend to make a collection of all the native kinds. Many other useful things he knows; speaks German and French equally well, English and Italian fairly, so that I have already appointed him to be my interpreter on some future vacation trip to Italy. He is well acquainted with ancient languages also, and studies medicine besides."

Schimper, another brilliant botanist, was a friend of both Braun and Agassiz. The professor in zoölogy, Leuckart, was very fond of these bright pupils, and allowed himself to be gotten up at seven in the morning, to give them extra lectures.

When vacation came, Braun took Agassiz to his home; a cultured place, rich in books, music, and collections of plants and animals. Agassiz was very happy there; possibly the happiness was increased by the fact that Braun had a lovely and artistic sister, Cecile. Agassiz wrote home, "My happiness would be perfect were it not for the painful thought which pursues me everywhere, that

I live on your privations; yet it is impossible for me to diminish my expenses further. You would lift a great weight from my heart if you could relieve yourself of this burden by an arrangement with my uncle at Neuchâtel. . . . Otherwise I am well, going on as usual, always working as hard as I can, and I believe all the professors whose lectures I attend are satisfied with me."

In the spring of 1827, when Agassiz was twenty, he was taken ill of typhus fever, and it was feared he would not recover. As soon as possible he was removed to Braun's home, and most tenderly cared for. When he became able, he went to his own home, at Orbe. From there he writes to Braun: "I had the good fortune to find at least thirty specimens of Bombinator obstetricans, with the eggs. Tell Dr. Leuckart that I will bring him some,—and some for you also. I kept several alive, laid in damp moss; after fourteen days the eggs were almost as large as peas, and the little tadpoles moved about inside in all directions. The mother stripped the eggs from her legs, and one of the little tadpoles came out, but died for want of water. Then I placed the whole mass of eggs in a vessel filled with water, and behold! in about an hour some twenty young ones were swimming freely about. I shall spare no pains to raise them, and I hope, if I begin aright, to make fine toads of them in the end. My oldest sister is busy every day in making drawings for me to illustrate their gradual development."

In the fall of 1827, Agassiz and Braun, after spending a little more than a year at Heidelberg, went to the University of Munich, there meeting Schimper. He wrote home, that from one of his windows he could see "the whole chain of the Tyrolean Alps, as far as Appenzell. . . . It is a great pleasure to have at least a part of our Swiss mountains always in sight. To enjoy it

the more, I have placed my table opposite the window, so that every time I lift my head my eyes rest on our dear country."

At Munich, the young students were stimulated by the presence of many noted men. Döllinger lectured on comparative anatomy; Schelling, on philosophy; Oken, on natural history, physiology, and zoölogy; Martius, on botany. Agassiz and Braun roomed in Döllinger's house. This room soon became the intellectual centre for the bright men of the college, and was called "the little academy." Here different students gave lectures, each on his special subject of study; the professors, even, coming as listeners.

"In that room," said Agassiz, years later, "I made all the skeletons represented on the plates of Wagler's 'Natural System of Reptiles'; there I once received the great anatomist Meckel, sent to me by Döllinger to examine my anatomical preparations, and especially the many fish-skeletons I had made from fresh-water fishes. By my side were constantly at work two artists; one engaged in drawing various objects of natural history, the other in drawing fossil fishes. I kept always one, and sometimes two artists, in my pay. It was not easy, with an allowance of two hundred and fifty dollars a year; but they were even poorer than I, and so we managed to get along together. My microscope I had earned by writing." Poor Agassiz! he was yet to see greater pecuniary trials than this.

Says Mr. Dinkel, one of the artists who worked with Agassiz for many years: "I soon found myself engaged four or five hours almost daily in painting for him fresh-water fishes from the life, while he was at my side, sometimes writing out his descriptions, sometimes directing me. . . . He never lost his temper, though often under great trial; he remained self-possessed, and

did everything calmly, having a friendly smile for every one, and a helping hand for those who were in need. He was at that time scarcely twenty years old, and was already the most prominent among the students of Munich. They loved him, and had a high consideration for him. . . . He liked merry society, but he himself was in general reserved, and never noisy. He picked out the gifted and highly learned students, and would not waste his time in ordinary conversation. Often, when he saw a number of students going off on some empty pleasure-trip, he said to me, 'There they go with the other fellows. . . . I will go my own way, Mr. Dinkel,—and not alone. I will be a leader of others.' "

Agassiz writes to his brother Auguste: "It will interest you to know that I am working with a young Dr. Born upon an anatomy and natural history of the freshwater fishes of Europe. We have already gathered a great deal of material, and I think by the spring, or in the course of the summer, we shall be able to publish the first number. . . . I earnestly advise you to while away your leisure hours with study. Read much, but only good and useful books. . . . Remember that statistical and political knowledge alone distinguishes the true merchant from the mere tradesmen, and guides him in his undertakings. . . . Write me about what you are reading, and about your plans and projects, for I can hardly believe that any one could exist without forming them; I, at least, could not."

It is not strange that the watchful mother begins to be anxious, for she hears nothing from her son about her "project" of medicine. She writes him that she detects in his letters "a certain sadness and discontent." "How is it," she says, "that you look forward only with distaste to the practice of medicine? Have you reflected seriously before setting aside this profession? Indeed,

we cannot consent to such a step; you would lose ground in our opinion, in that of your family, and in that of the public you would pass for an inconsiderate, fickle young fellow, and the slightest stain on your reputation would be a mortal blow to us. . . . Of course you will not gather roses without thorns. Life consists of pains and pleasures everywhere. To do all the good you can to your fellow-beings, to have a pure conscience, to gain an honorable livelihood, to procure for yourself by work a little ease, to make those around you happy, that is true happiness; all the rest but mere accessories and chimeras."

And then the good Swiss minister adds, thus to quiet his son's restless nature, "If it be absolutely essential to your happiness that you should break the ice of the two poles in order to find the hairs of a mammoth, . . . at least wait till your trunk is packed and your passports are signed before you talk with us about it. Begin by reaching your first aim, a physician's and surgeon's diploma. . . . My own philosophy is to fulfil my duties in my sphere, and even that gives me more than I can do." Fortunately Louis Agassiz did not possess the kind of philosophy that brings content in a small parish on a Swiss lake; his sphere was to be the world, and two continents were to be proud of him.

In 1817, the King of Bavaria had sent two naturalists, M. Martius and M. Spix, on an exploring expedition to Brazil. They returned in four years, laden with treasures. M. Martius issued colored illustrations of all the unknown plants he had collected, and M. Spix several volumes on the monkeys, birds, and reptiles of Brazil. He had intended to give a complete natural history of Brazil, but died before his work was finished. Martius asked Agassiz to continue the work of Spix, in the line of fishes.

Agassiz writes to his sister Cecile: "I hesitated for

a long time to accept this honorable offer, fearing that the occupation might withdraw me too much from my studies; but, on the other hand, the opportunity for laying the foundation of a reputation by a large undertaking seemed too favorable to be refused. The first volume is already finished, and the printing was begun some weeks ago. . . . Already forty colored folio plates are completed. Will it not seem strange when the largest and finest book in papa's library is one written by his Louis? Will it not be as good as to see his prescription at the apothecary's? It is true that this first effort will bring me in but little; nothing at all, in fact, because M. de Martius has assumed all the expenses, and will, of course, receive the profits. My share will be a few copies of the book, and these I shall give to the friends who have the first claim."

He writes to his father, as though half apologizing for the fact that he is writing a book on natural history, at the same time showing the real purpose of his life: "I wish it may be said of Louis Agassiz that he was the first naturalist of his time, a good citizen, and a good son, beloved of those who knew him. I feel within myself the strength of a whole generation to work toward this end, and I will reach it if the means are not wanting."

Thus early in life he had fixed the mark to which he would attain, "the first naturalist of his time." No wonder he succeeded, when he felt within himself "the strength of a whole generation to work toward this end."

In the summer of 1829, when he was twenty-two, the first part of the "Brazilian Fishes" was published, and a copy sent to the fond parents. Good M. Agassiz wrote back: "I have no terms in which to express the pleasure it has given me. In two words, for I have only a moment to myself, I repeat my urgent entreaty that you would hasten your return as much as possible. . . . The

old father, who waits for you with open heart and arms, sends you the most tender greeting." He had been devoting his time to science—just what they feared,—but how proud they were to have him succeed!

Cuvier, the great leader in zoölogy, to whom the book was dedicated, wrote back: "You and M. de Martius have done me honor in placing my name at the head of a work so admirable as the one you have just published. The importance and the rarity of the species therein described, as well as the beauty of the figures, will make the work an important one in ichthyology, and nothing could heighten its value more than the accuracy of your descriptions. It will be of the greatest use to me in my 'History of Fishes.' . . . I shall do all in my power to accelerate the sale among amateurs, either by showing it to such as meet at my house, or by calling attention to it in scientific journals."

Another project had now taken form in Agassiz's active brain, his great work on "Fossil Fishes," which a few years later placed him in the front rank of scientific men. He wrote to Auguste: "Having, by permission of the director of the museum, one of the finest collections of fossils in Germany at my disposition, and being also allowed to take the specimens home as I need them, I have undertaken to publish the ichthyological part of the collection. Since it only makes the difference of one or two people more to direct, I have these specimens also drawn at the same time. Nowhere so well as here, where the Academy of Fine Arts brings together so many draughtsmen, could I have the same facility for completing a similar work; and as it is an entirely new branch, in which no one has as yet done anything of importance, I feel sure of success; the more so because Cuvier, who alone could do it (for the single reason that every one else has till now neglected the fishes), is not engaged

upon it. Add to this that just now there is a real need of this work for the determination of the different geological formations." And then he urges Auguste to intercede with his uncle at Neuchâtel for one hundred louis. "At this very time, when he was keeping two or three artists on his slender means," says his wife, "he made his own breakfast in his room, and dined for a few cents a day at the cheapest eating-houses. But where science was concerned the only economy he recognized, either in youth or old age, was that of an expenditure as bold as it was carefully considered."

He was now at work finishing the "Brazilian Fishes," and carrying forward the "Fresh-Water Fishes" and the "Fossil Fishes." Besides these, he read medical works till midnight, and wrote seventy-four theses on anatomical, pathological, surgical, and obstetrical subjects.

He took his degree of medicine April 3, 1830. He writes to his mother:

The whole ceremony lasted nine days. At the close, while they considered my case, I was sent out of the room. On my return, the dean said to me, "The faculty have been *very much*" (emphasized) "pleased with your answers; they congratulate themselves on being able to give the diploma to a young man who has already acquired so honorable a reputation." . . . The rector then added that he should look upon it as the brightest moment of his rectorship when he conferred upon me the title I had so well merited.

And the glad mother writes back:

I cannot thank you enough, my dear Louis, for the happiness you have given me in completing your medical examinations, and thus securing to yourself a career as safe as it is honorable. . . . You have for my sake gone through a long and arduous task; were it in my power I would gladly

reward you, but I cannot even say I love you the more for it, because that is impossible. My anxious solicitude for your future is a proof of my ardent affection for you; only one thing was wanting to make me the happiest of mothers, and this, my Louis, you have just given me.

Agassiz had taken the degree of Doctor of Philosophy, a year earlier. "The time had come," said he, years afterward, "when even the small allowance I received from borrowed capital must cease. I was now twenty-four years of age. I was Doctor of Philosophy and Medicine, and author of a quarto volume on the fishes of Brazil. I had travelled on foot all over Southern Germany, visited Vienna, and explored extensive tracts of the Alps. I knew every animal, living and fossil, in the museums of Munich, Stuttgart, Tübingen, Erlangen, Wurzburg, Carlsruhe, and Frankfort; but my prospects were as dark as ever, and I saw no hope of making my way in the world, except by the practical pursuit of my profession as physician."

December 4, 1830, Agassiz said good-bye to Munich, and started with Mr. Dinkel, his artist, for Concise, his father having moved there from Orbe. Here he remained a year, arranging, meantime, his own valuable collections in natural history, at the house of his grandfather Mayor, at Cudrefin, on Lake Neuchâtel, and practising a little in medicine, in the neighboring villages.

He longed to go to Paris for study, but poverty was his constant companion. Finally, an old friend of his father, a Swiss clergyman, M. Christinot, having come into possession of a small amount of money, urged his young friend to take it. His uncle also contributed a little, and Agassiz and Dinkel left for Paris in September, 1831.

On their arrival they found inexpensive lodgings, and

at once began to work in the museums. He writes to his sister Olympe:

M. Cuvier and M. Humboldt especially treat me on all occasions as an equal, and facilitate for me the use of the scientific collections so that I can work here as if I were at home. . . . In the morning I follow the chemical courses at the Pitié. . . . At ten o'clock, or perhaps at eleven, I breakfast, and then go to the Museum of Natural History, where I stay till dark. Between five and six I dine, and after that turn to such medical studies as do not require daylight. . . . On Saturday only, I spend the evening at M. Cuvier's.

He writes later to his brother that there is another excellent reason why he does not spend more evenings in society, because he has "no presentable coat. . . . You can imagine that, after the fuel bill for the winter is paid, little remains for other expenses out of my two hundred francs a month, five louis of which are always due to my companion. Far from having anything in advance, my month's supply is thus taken up at once." Evidently he had no more money than when he and Auguste copied whole volumes at the Zurich school.

Cuvier was so much drawn to the young naturalist that he gave him and his artist a corner in one of his own laboratories, and, more than this, his drawings of fossil fishes and notes which he had taken in the British Museum and elsewhere. Cuvier said, three months later, with regard to some work, "You are young; you have time enough for it, and I have none to spare."

Agassiz now studied fifteen hours daily, sometimes seventeen. Cuvier commended his devotion, but said one evening as he left him, "Be careful, and remember that *work kills*." The next day he was paralyzed and died soon after, Agassiz never seeing him again.

It became evident that Paris, with her scientific

treasures, could not be enjoyed longer. He must go back to Switzerland, and find a place to teach, as his sympathetic mother urged him to do. Just when the sky was darkest, a letter came from Humboldt, enclosing a check for one thousand francs! "Consider it," he said, "an advance which need not be paid for years, and which I will gladly increase when I go away or even earlier. It would pain me deeply should the urgency of my request, made in the closest confidence,—in short, a transaction as between two friends of unequal age,—be disagreeable to you. I should wish to be pleasantly remembered by a young man of your character. Yours, with the most affectionate respect, Alexander Humboldt."

How delicately offered was this charity in the guise of a loan! To give is blessed; to give without wounding the recipient is more blessed still!

The tender heart of Agassiz was deeply moved. He wrote his mother:

Oh! if my mother would forget for one moment that this is the celebrated M. de Humboldt, and find courage to write him only a few lines, how grateful I should be to her. I think it would come better from her than from papa, who would do it more correctly, no doubt, but perhaps not quite as I should like.

She wrote a thankful letter, and the great man replied:

I should scold your son, madame, for having spoken to you of the slight mark of interest I have been able to show him; and yet, how can I complain of a letter so touching, so noble in sentiment, as the one I have just received from your hand? Accept my warmest thanks for it. . . . One might well despair of the world if a person like your son, with information so substantial and manners so sweet and prepossessing, should fail to make his way.

This money made it possible for Agassiz to work in Paris, until a professorship of Natural History was created for him at Neuchâtel, through the influence of Humboldt and others. Humboldt wrote: "Agassiz is distinguished by his talents, by the variety and substantial character of his attainments, and by that which has a special value in these troubled times, his natural sweetness of disposition."

This "sweetness of disposition" was worth more to Agassiz, all through life, than a fortune. It drew everybody to him. It opened the pockets of the wealthy to carry forward his great projects. It won the hearts of his pupils on two hemispheres. It made his home a delight, and his presence a constant blessing.

He assumed the duties of his professorship at Neuchâtel in the autumn of 1832, giving his first lecture, "Upon the Relations between the different branches of Natural History and the then prevailing tendencies of all the Sciences," November 12, at the Hôtel de Ville. A society for the study of the natural sciences was formed, and Agassiz became its secretary. So natural, so enthusiastic, so full of his subject, was he, that everybody became interested. To little companies of his friends and neighbors he lectured on botany, on zoölogy, and the philosophy of nature. Even the children were delighted to gather and be told how lakes, springs, rivers, and valleys are formed.

"When it was impossible to give the lessons out-of-doors, the children were gathered around a large table, where each one had before him or her the specimens of the day, sometimes stones and fossils, sometimes flowers, fruits, or dried plants. . . . When the talk was of tropical or distant countries, pains were taken to procure characteristic specimens, and the children were introduced to dates, bananas, cocoanuts, and other fruits,

not to be easily obtained in those days in a small inland town. They, of course, concluded the lesson by eating the specimen, a practical illustration which they greatly enjoyed."

Three months after his settlement at Neuchâtel, where eighty louis had been guaranteed to him for three years, he was invited to Heidelberg, to succeed his former professor, Leuckart, in zoölogy. He would receive a salary of five hundred florins, besides about fifteen hundred gulden for lectures and literary work. He declined the honor, because he wished more time to devote to his writing. The following year Neuchâtel purchased his collections in natural history, thus affording him some pecuniary aid in his work.

A serious misfortune now threatened him in the loss of sight. Having injured his eyes by microscopic work, for several months he was shut up in a dark room, practising the study of his fossils by touch alone; by the tongue when the fingers were not sufficiently sensitive to feel out the impression. With great care his eyes improved, so that he was able to use them through life more constantly than most persons.

In October, 1833, when he was twenty-six, Agassiz married Cecile Braun of Carlsruhe, the sister of his lifelong friend Alexander. They began housekeeping in a small apartment at Neuchâtel, both practising the closest economy that the books might be carried on; the "Fresh-Water Fishes," and the "Fossil Fishes." She was a skilful artist, had done much work for her brother in botany, and now helped her young husband in drawing and coloring his fishes.

The first number of the "Fossil Fishes" had already appeared, with the following title, which shows the plan of the great work, to which he devoted ten years, from 1833 to 1843:——

"Researches on the Fossil Fishes: comprising an Introduction to the Study of these Animals; the Comparative Anatomy of Organic Systems which may contribute to facilitate the Determination of Fossil Species; a New Classification of Fishes, expressing their relations to the Series of Formations; the Explanation of the Laws of their Succession and Development during all the Changes of the Terrestrial Globe, accompanied by General Geological Considerations; finally, the Description of about a thousand Species which no longer exist, and whose Characters have been restored from Remains contained in the Strata of the Earth."

The work was inscribed to Humboldt. "These pages owe to you their existence; accept their dedication." It met everywhere the most favorable reception. Élie de Beaumont wrote to Agassiz: "It promises a work as important for science as it is remarkable in execution. Do not let yourself be discouraged by obstacles of any kind; they will give way before the concert of approbation which so excellent a work will awaken."

Agassiz had become known to scholars throughout Europe, as an indefatigable worker, but he was still poor. Now and then there came a gleam of sunshine into the straitened life. In 1834, he was greatly surprised to receive from the London Geological Society, through Sir Charles Lyell, the Wollaston prize, of about one hundred and fifty dollars, conferred upon him for his work on fishes.

He writes back to Lyell:

You cannot imagine the joy your letter has given me. The prize awarded me is at once so unexpected an honor and so welcome an aid that I could hardly believe my eyes when, with tears of relief and gratitude, I read your letter. In the presence of a savant, I need not be ashamed of my

penury, since I have spent the little I had wholly in scientific researches. I do not, therefore, hesitate to confess to you that at no time could your gift have given me greater pleasure. Generous friends have helped me to bring out the first number of my "Fossil Fishes"; the plates of the second are finished, but I was greatly embarrassed to know how to print a sufficient number of copies before the returns from the first should be paid in. The text is ready also, so that now, in a fortnight, I can begin the distribution, and, the rotation once established, I hope that preceding numbers will always enable me to publish the next in succession without interruption. I even count upon this resource as affording me the means of making a journey to England before long.

In August, 1834, Agassiz went to England, and there formed delightful friendships with such men as Lyell, Murchison, Buckland, and others. He was allowed to cull, from sixty or more collections, some two thousand fossil fishes, and deposit them in the Somerset House in London, where Mr. Dinkel, the artist, remained for several years at work, copying.

In the summer of 1836, he began his remarkable study of the glaciers. He was so cramped for means to carry forward his "Fossil Fishes," that it seemed probable that he must discontinue it, when opportunely his original drawings were purchased by Lord Francis Egerton and given to the British Museum. The financial condition was thus bettered for a time.

His investigation of the slopes of the Jura led to an address before the Helvetic Association assembled at Neuchâtel in 1837, in which he said: "Siberian winter established itself for a time over a world previously covered with a rich vegetation and peopled with large mammalia, similar to those now inhabiting the warm regions of India and Africa. Death enveloped all nature

in a shroud, and the cold, having reached its highest degree, gave to this mass of ice, at the maximum of tension, the greatest possible hardness." He showed how huge boulders had been distributed over the continent.

His views excited much opposition, from most of the older geologists. Even Humboldt said, "Your ice frightens me." But the discussion convinced the scientific world that Agassiz was both original and brilliant. He was soon called to a professorship of geology and mineralogy at Geneva, with a salary of three thousand francs, and also to Lausanne; but he refused both offers. So pleased were the people of Neuchâtel that they made him accept a present of six thousand francs, payable during three years.

In 1838, Agassiz founded a lithographic printing establishment in Neuchâtel, where his work could be done under his own direction instead of in Munich. He was now, besides his duties as professor, at work on "Living and Fossil Echinoderms and Mollusks," as well as "Fresh-Water and Fossil Fishes," and soon after upon the "Studies on the Glaciers," with an atlas of thirty-two plates. The book gave an account of all previous glacial study, and the observations of himself and companions.

"Agassiz displayed during these years," said one of his co-workers, "an incredible energy, of which the history of science offers, perhaps, no other example." He worked always till midnight, often till two or three o'clock, sitting for hours at his microscope, troubled much with congestion of the head and eyes. The expense involved in his work was enormous, and he was burdening himself with debts, which are more wearing and destructive to health and happiness than any amount of work can ever be.

Still he struggled on, through these dark days of poverty. He was only thirty-three, so young-looking that, on seeing him, people asked if he were "the son of the celebrated professor of Neuchâtel." He had already been chosen a member of the Royal Society of London.

In 1840 he made his first permanent station on the Alps, taking with him barometers, thermometers, hygrometers, psychometers, boring apparatus, and microscopes, making the Hospice of the Grimsel his base of supplies, and the lower Aar glacier the scene of his work. A huge boulder, its upper surface forming a roof, with a stone wall constructed on one side, became the sleeping-room of Agassiz and five friends. This abode was called the Hôtel des Neuchâtelois. Jacob Leuthold, an intrepid Swiss, was their chief guide. He died at thirty-seven, sincerely mourned by all. They made dangerous ascents of snow-covered peaks, measured the depth and forward movement of glaciers, Agassiz even being lowered by ropes one hundred and twenty-five feet into a glacial well, to investigate its formation.

All Europe was becoming interested in glaciers. Edward Forbes wrote from Edinburgh:

You have made all the geologists glacier-mad here, and they are turning Great Britain into an ice-house. Darwin was deeply interested. He wrote from North Wales: "The valley about here and the site of the inn at which I am now writing must once have been covered by at least eight hundred or one thousand feet in thickness of solid ice! Eleven years ago I spent a whole day in the valley where yesterday everything but the ice of the glaciers was palpably clear to me, and I then saw nothing but plain water and bare rock."

Agassiz now began work on his "Nomenclator Zoölogicus," and his "Bibliographia Zoölogiæ et Geologiæ," the former comprising "an enumeration of all

the genera of the animal kingdom, with the etymology of their names, the names of those who had first proposed them, and the date of their publication." The latter contained a list of all the authors named in the Nomenclator, with notices of their works. This was published by the Royal Society in England, in 1848, the expense being too great for one person.

In 1843 the "Fossil Fishes," in five large volumes, was completed, and the following year his "Monograph on the Fossil Fishes of the Old Red Sandstone, or the Devonian System of Great Britain and Russia," was published, a large volume accompanied by forty-one plates. The discovery of these fossils was due to Hugh Miller, whose interesting life and pathetic death will always be associated with the study of the Old Red Sandstone.

In the spring of 1846, a great change took place in the life of the overworked naturalist. He had long hoped to visit the United States for scientific investigation, and now the time had come. The King of Prussia, at the request of Humboldt, granted him fifteen thousand francs for this purpose—he had previously given Agassiz one thousand dollars for his glacial researches. . . . Leaving his wife and daughters with Alexander Braun, her brother, at Carlsruhe, and his son Alexander at school at Neuchâtel, Agassiz said good-bye to his students, who came at two o'clock at night, in procession with torchlights. Going to Paris, he spent some time in bringing out his second work upon the glaciers, "Système Glaciaire," receiving the Monthyon Prize of Physiology from the Academy, and sailed for America in September, 1846.

Humboldt wrote him from Sans-Souci:

Be happy in this new undertaking, and preserve for me the first place under the head of friendship in your heart. When you return, I shall be here no more, but the king and

queen will receive you on this historic hill with the affection which, for so many reasons, you merit. Your illegible but much attached friend.

Sir Charles Lyell, of England, who had given a successful course of lectures before the Lowell Institute, Boston, arranged a similar course with Mr. Lowell for his friend Agassiz. Perhaps money has never been given more wisely in our country than by the refined John Lowell, Jr., of Boston, who, dying in a foreign country at thirty-seven, bereft of wife and children, left a quarter of a million dollars to "provide for regular courses of *free* public lectures upon the most important branches of natural and moral science, to be annually delivered in the city of Boston." None of the bequest could be used for buildings, and ten per cent. of the accumulation of the fund was to be set aside annually to continue it. Since December 1, 1839, from six to ten courses have been given yearly to large audiences, by some of the most distinguished scientists and scholars in both Europe and America.

"Natural and moral science!" How broad the subject, and how incalculable the benefit to any city, great or small! What a means for the best general education; what an uplifting of the whole mental and social life of a community!

Agassiz came to Boston and gave twelve lectures on the "Plan of the Creation, especially in the Animal Kingdom." His speech had a foreign accent; but his enthusiastic love of his subject, his skill in drawing on the blackboard, and his eloquent but simple language soon won all hearts.

He was as pleased with the Americans as they were with him. He wrote to his beloved mother (his father had died ten years before): "I can only say that the

educated Americans are very accessible and very pleasant. They are obliging to the utmost degree; indeed, their cordiality toward strangers exceeds any that I have met elsewhere. . . . The liberality of the American naturalists toward me is unparalleled. . . . The government (of the State of New York) has just completed the publication of a work unique of its kind, a natural history of the State in sixteen volumes, quarto, with plates. Twenty-five hundred copies have been printed, only five hundred of which are for sale, the rest being distributed throughout the State. Four volumes are devoted to geology and mining alone; the others, to zoölogy, botany, and agriculture. Yes, twenty-five hundred copies of a work in sixteen volumes, quarto, scattered throughout the State of New York alone!

"When I think that I began my studies in natural history by copying hundreds of pages from a Lamarck which some one had lent me, and that today there is a state in which the smallest farmer may have access to a costly work, worth a library to him in itself, I bless the efforts of those who devote themselves to public instruction."

Agassiz was at once asked to give a second course before the Lowell Institute, on glaciers. This, like the first, was greatly enjoyed by the two thousand or more persons present. Invitations now came from other cities, but he said, "I will limit myself to what I need in order to repay those who have helped me through a difficult crisis. . . . Beyond that all must go again to science,—there lies my true mission."

He passed his fortieth birthday, May 28, 1847, with Dr. B. E. Cotting, curator of the Lowell Institute, at whose home he had stayed through some weeks of illness. His host, seeing him standing thoughtfully at the window, said, "Why so sad?"

"That I am so old and have done so little," was the reply.

In the summer of 1847, Agassiz rented a small house in East Boston, sufficiently near to the ocean to study marine animals. He also gave lectures in New York, Philadelphia, Albany, and other eastern cities.

The next spring, the Lawrence Scientific School was organized at Cambridge, in connection with Harvard University, and Agassiz was offered the chair of Natural History (zoölogy and geology), with a salary of fifteen hundred dollars. The school owed its existence to Abbott Lawrence, formerly our minister to England.

Agassiz accepted the position, and opened his first course in April, 1848. Here he found congenial friends, Longfellow, Lowell, Prescott, Motley, Gray, Holmes, and others. M. Christinot, who had so generously helped to send him to Paris years before, came to the Cambridge home and was put in charge of it. "If your old friend," he said, "can live with his son Louis, it will be the height of his happiness."

The small plot of ground about the house became a zoölogical garden, with its tank for turtles and an alligator, its cage for eagles, a tame bear, and a family of opossums. Agassiz had already begun his Museum of Comparative Zoölogy, on the banks of the Charles River, in an old shanty. The outlook was hopeful; but he was sad at heart, for Cecile, his wife, had died since he came to America, and his children seemed too young to bring into a home where there was no mother.

In the summer of 1848, Agassiz organized an expedition of students and naturalists for the examination of the eastern and northern shores of Lake Superior. At Niagara, he saw for the first time a living garpike, the only representative among modern fishes of the fossil type of Lepidosteus. He made a careful study of the

fauna and geology of the lake, and the results were published in a book. Charles Darwin wrote:

> I have seldom been more deeply gratified than by receiving your most kind present of "Lake Superior." . . . I had heard of it, and had much wished to read it, but I confess it was the very great honor of having in my possession a work with your autograph as a presentation copy that has given me such lively and sincere pleasure.

Agassiz had published another book in America, in 1848, "Principles of Zoölogy," which had a large sale, and was much used in schools. In 1849, his only son, fifteen years old, came to live with his father. The following year, 1850, Agassiz married Elizabeth Cabot Cary, of Boston, a cultivated and lovely woman. His daughters, much younger than their brother, arrived from Europe the same year. M. Christinot, though urged to remain, now preferred to find another home, settled in New Orleans as pastor, and later died in Switzerland.

The winter of 1851 was spent in the examination of the Florida reefs and keys, a work undertaken at the request of Prof. A. D. Bache, at the head of the United States Coast Survey. The results were valuable in showing "how far the soil now building up from accumulations of mud and coral débris was likely to remain for a long time shifting and uncertain, and how far and in what localities it might be relied upon as affording a stable foundation," for building lighthouses, etc. Agassiz brought back for his museum a fine collection of corals, of all varieties and in all stages of growth, with drawings made on the spot, from the living animals.

This year he accepted a professorship at the medical college in Charleston, S. C., lecturing during the three winter months, between his autumn and spring courses at Cambridge. The overwork finally resulted in a

dangerous illness, and he was obliged to discontinue it in 1853 The year previous he received the Prix Cuvier for his "Fossil Fishes." His fond mother wrote: "This has given me such happiness, dear Louis, that the tears are in my eyes as I write it to you."

He now issued a circular asking for collections of fishes from various fresh-water systems of the United States, and responses came from every direction. New England captains, when they started on a cruise, took out cans, furnished by Agassiz, for collections in distant ports. Fishermen and farmers, indeed all classes, heartily joined in coöperating with the man who had said in the University at Munich, "I will be a leader of others," and he had reached the mark which he set for himself. In 1854 he was urged to accept a professorship in the recently established University of Zurich, Switzerland; but he declined, for he had one definite aim in America, to found a great museum, where the best methods of study could be adopted. He said in his "Fossil Fishes": "Possessing no fossil fishes myself, and renouncing forever the acquisition of collections so precious, I have been forced to seek the materials for my work in all the collections of Europe containing such remains; I have, therefore, made frequent journeys in Germany, in France, and in England, in order to examine, describe, and illustrate the objects of my researches; but, notwithstanding the cordiality with which even the most precious specimens have been placed at my disposition, a serious inconvenience has resulted from this mode of working, namely, that I have rarely been able to compare directly the various specimens of the same species from different collections, and that I have often been obliged to make my identification from memory, or from simple notes, or, in the more fortunate cases, from my drawings only. It is impossible to imagine the fatigue, the exhaustion of

all the faculties, involved in such a method." He hoped to found a museum where students should have specimens for work, ready for their use.

In the winter of 1855, Agassiz resumed his public lectures, as his salary of fifteen hundred was insufficient to support his family, but when the spring came he found himself exhausted by the extra work.

And now his noble wife thought out a plan to aid him. She opened a school in their house, for young ladies. Agassiz's surprise and pleasure knew no bounds when he was informed of the project. He immediately took charge of the classes in physical geography, natural history, and botany, giving a lecture daily on one or other of these subjects. The school, with sixty or seventy girls, was continued for eight years, Agassiz having the coöperation of his brother-in-law, Professor Felton, the noted Greek scholar, and other distinguished men. This school was a blessing in more ways than one. All these years, the debts incurred by the publication of the "Fossil Fishes," and the glacial investigations, had burdened him. The wonder was that the genial, untiring worker could labor at all under this depressing load. Noble devotees to science! What have they not suffered to advance the cause of knowledge! We sit by our pleasant firesides and read what others have wrought for us, perhaps in want and sorrow of soul, and we forget to be grateful or to help lift burdens.

This school opened by the helpful wife made Agassiz a free man—no longer shackled by that worst form of slavery, debt. Well said John Ruskin: "My first word to all men and boys who care to hear me is, don't get into debt. Starve and go to heaven, but don't borrow. . . . Don't buy things you can't pay for!"

Indefatigable, versatile, comprehensive in mind, Agassiz at once planned another great work, to be published in

ten volumes, though it was finally reduced to four: "Contributions to the Natural History of the United States." Mr. Francis C. Gray of Boston, a personal friend and a lover of letters and science, set the subscription before the public. Very soon, to Agassiz's great delight, he received the names of seventeen hundred subscribers, at twelve dollars a volume.

He had now reached his fiftieth birthday, completing his first volume of the new work on that day. His students serenaded him, and Longfellow wrote, to be read at the "Saturday Club," composed of Hawthorne, Holmes, Lowell, Dana, and others, this exquisite poem:—

It was fifty years ago,
  In the pleasant month of May,
In the beautiful Pays de Vaud,
  A child in its cradle lay.

And Nature, the old nurse, took
  The child upon her knee,
Saying: "Here is a story-book
  Thy Father has written for thee."

"Come wander with me," she said,
  "Into regions yet untrod,
And read what is still unread
  In the manuscripts of God."

And he wandered away and away
  With Nature, the dear old nurse,
Who sang to him night and day
  The rhymes of the universe.

And whenever the way seemed long,
  Or his heart began to fail,

She would sing a more wonderful song,
  Or tell a more marvellous tale.

So she keeps him still a child,
  And will not let him go,
Though at times his heart beats wild
  For the beautiful Pays de Vaud;

Though at times he hears in his dreams
  The Ranz des Vaches of old,
And the rush of mountain streams
  From glaciers clear and cold;

And the mother at home says, "Hark!
  For his voice I listen and yearn;
It is growing late and dark,
  And my boy does not return!"

This year, 1857, Agassiz received an unexpected honor —a call to one of the most coveted places at the Jardin des Plantes; the chair of palæontology in the Museum of Natural History, Paris. Though obliged to refuse it because he considered his life-work to be in America, he appreciated the favor as also the bestowal of the Order of the Legion of Honor, and the Copley medal from England. Twenty-seven years before, he had received in Paris the aid of Humboldt in his destitution; now, two hemispheres competed for his services.

The following year, 1858, Mr. Francis C. Gray died, leaving fifty thousand dollars for the establishment of a Museum of Comparative Zoölogy, to be used neither for buildings nor for salaries, but purely for scientific needs.

"All things come round to him who will but wait," says Longfellow, in the "Falcon of Sir Federigo." Other gifts soon followed. Harvard University gave land for the site of the building. The Massachusetts Legislature

gave lands to the amount of one hundred thousand dollars. Over seventy-one thousand was promptly subscribed by citizens of Boston and Cambridge. Agassiz contributed all his collections, worth thousands of dollars. The corner-stone of the museum was laid one sunny afternoon in June, 1859, and then the happy Agassiz hastened across the ocean, to rejoice with his mother, in her home near the foot of the Jura. She was glad and proud now that he had become a naturalist.

The museum was dedicated November 13, 1860. The plan included a main building 364 feet long, with wings 205 long, the whole enclosing a hollow square. The lecture rooms were at once opened. Especially welcome were teachers of schools, for whom admittance was free. His lectures were open to women as well as to men. This would naturally be expected, from the broad-mindedness of the man, and the respect he must have had for the capacity of woman, from such a mother and such a wife. "He had great sympathy," says Mrs. Agassiz, "with the desire of women for larger and more various fields of study and work." To such men women can never be too grateful.

In 1863, he helped to organize the National Academy of Sciences. He frequently gave lectures in the large cities, using the money for the further development of the museum.

In 1865 he started, with his wife and several assistants, for sixteen months of scientific investigations in Brazil, the expenses borne by his friend, Mr. Nathaniel Thayer, of Boston. He writes to his mother,——

All those who know me seem to have combined to heighten the attraction of the journey, and facilitate it in every respect. The Pacific Mail Steamship Company have invited me to take passage with my whole party on their fine

steamer, the Colorado. They will take us, free of all expense, as far as Rio de Janeiro,—an economy of fifteen thousand francs at the start. . . . I seem like the spoiled child of the country, and I hope God will give me strength to repay, in devotion to her institutions and to her scientific and intellectual development, all that her citizens have done for me. . . .

With all my heart,

YOUR LOUIS.

The story of this expedition has been told, chiefly by Mrs. Agassiz, in that most interesting volume, "A Journey in Brazil."

On Agassiz's return, he gave a course of lectures before the Lowell Institute, and the Cooper Institute, New York, spending the summer at his pleasant seaside home and laboratory at Nahant.

The fishermen at Nahant would pull two or three miles to bring him a rare fish; and only for the pleasure of seeing him rush out of his little laboratory, crying: "Oh! where did you get that? That is a species which goes as far as Brazil. Nobody has ever seen it north of Cape Cod. Come in, come in, and sit down!"

In 1868, Agassiz, invited by Mr. Samuel Hooper, joined a party of friends in an excursion to the Rocky Mountains. This year he was appointed non-resident professor at Cornell University, Ithaca, New York.

The Massachusetts Legislature now gave seventy-five thousand dollars, and private individuals an equal sum, to provide for the new collections at the museum. Later, the museum received from the Legislature twenty-five thousand more, and a birthday gift to Agassiz, of one hundred thousand dollars, was also used by him for his precious work. September 15, 1869, at the Humboldt Centennial Celebration, Agassiz delivered an eloquent address before the Boston Society of Natural History,

and the "Humboldt Scholarship" was founded at the museum. The bread cast upon the waters by Humboldt had been found after many days.

Agassiz was now completely prostrated by overwork, and told by his physician that for the several months in which he remained shut up in his room he must not think. Yet he could not banish one subject from his thoughts, and, with tears in his eyes, he would sometimes exclaim,—"Oh, my museum! my museum! always uppermost, by day and by night, in health and in sickness, always—*always!*"

The great mind rallied for one more voyage of research in his beloved science. In the coast-survey steamer *Hassler,* with his wife and friends, he sailed December 4, 1871, around Cape Horn, landing at several places along the coast, gathering rich treasures from deep-sea dredgings, entering the Golden Gate, August 24, 1872.

In October, Agassiz returned to Cambridge. Through the gift of Mr. John Anderson, a wealthy New York merchant, of the island of Penikese, in Buzzard's Bay, with its buildings and an endowment of fifty thousand dollars, a summer school of natural history was at once opened. This year was a very busy one. A series of articles were in preparation for the "Atlantic Monthly," in opposition to the views of Darwin on evolution. He had already published two successful books, "Methods of Study in Natural History," and "Geological Sketches." December 2, 1873, a lecture was given at Fitchburg, before a meeting of the Massachusetts Board of Agriculture. The next day Agassiz spoke of dimness of sight, and of feeling "strangely asleep," and on December 14 he was asleep in death.

He was buried from the college chapel, the students

who loved him laying a wreath of laurel upon the bier, and singing his requiem. The noble mother, fortunately, had died six years before him.

They buried him at Mount Auburn. From the glacier of the Aar, not far from the spot where his little hut once stood, they brought a boulder for his monument, and from his old home in Switzerland, pine trees to grow beside his grave. He loved both countries, and both have shared in his sacred resting-place.

His work will never cease. His museum at Cambridge now has seventy-one rooms and twelve galleries, with invested funds of over five hundred and eighty thousand dollars, while the buildings and collections are valued at about seven hundred thousand dollars. It was later under the charge of Prof. Alexander Agassiz, the son of Louis, and to his constant generosity and devotion the museum was also deeply indebted.

Agassiz said, "My hope is that there shall arise upon the grounds of Harvard a museum of natural history which shall compete with the British Museum and with the Jardin des Plantes. Do not say it cannot be done, for you cannot suppose that what exists in England and France cannot be reached in America. I hope even that we shall found a museum which will be based upon a more suitable foundation, and better qualified to advance the highest interests of science than these institutions of the old world."

Agassiz not only wrote books and built museums. He gave to the world a high ideal of a seeker after truth. He stimulated the intellectual activity of two continents, and blessed both of them by his own brilliant mind and his noble character.

CHARLES ROBERT DARWIN

On Wednesday, April 26, 1882, sitting in the North Transept of Westminster Abbey, I looked upon a sad and impressive scene. Under the dome stood an oaken coffin, quite covered with white wreaths; close by were seated the distinguished pall-bearers, Sir John Lubbock, Canon Farrar, the Duke of Argyle, Thomas H. Huxley, James Russell Lowell, and others. Representatives of many nations were present; the great scientists of France, Germany, Italy, Spain, and Russia.

Of the thousands who were gathered to honor the famous dead, every person wore black, as requested on the cards of admission to the abbey. Perhaps never in the history of England have so many noted men been assembled on an occasion like this. As the choir, in their white robes, stood about the open grave, singing the "Dead March from Saul," the strains seemed to come from a far-off country, producing an effect never to be forgotten. Darwin lies buried close to the graves of Sir Isaac Newton and Sir John Herschel.

At Shrewsbury, England, February 12, 1809, Charles Robert Darwin was born, in a square, red-brick house at the top of a terraced bank leading down to the Severn. The greenhouse with its varied plants, the ornamental shrubs and trees in the grounds, became a delight as soon as the boy was old enough to observe them.

The mother, Susannah, the daughter of Josiah Wedgwood of Etruria, a woman with a sweet and happy face, died when Charles was eight years old, leaving five other children; Marianne, Caroline, Erasmus, Susan, and

Catherine. Charles says of her in his autobiography, "It is odd that I can remember hardly anything about her except her death-bed, her black velvet gown, and her curiously constructed work-table." She evidently encouraged the boy's love for flowers, for he used to say, at school, that his mother had taught him "how, by looking at the inside of the blossom, the name of the plant could be discovered."

The father, Robert Waring Darwin, was a well-known physician, a man of fine physique and courtly manner, who had amassed wealth by his skill and business ability. Charles's admiration of him was unbounded: "the wisest man I ever knew," he used often to say.

"His chief mental characteristics," said Darwin, "were his powers of observation and his sympathy, neither of which have I ever seen exceeded or even equalled. His sympathy was not only with the distresses of others, but in a greater degree with the pleasures of all around him. This led him to be always scheming to give pleasure to others, and, though hating extravagance, to perform many generous actions. For instance, Mr. B——, a small manufacturer in Shrewsbury, came to him one day, and said he should be bankrupt unless he could at once borrow ten thousand pounds, but that he was unable to give any legal security. My father heard his reasons for believing that he could ultimately repay the money, and, from his intuitive perception of character, felt sure that he was to be trusted. So he advanced this sum, which was a very large one for him while young, and was after a time repaid.

"I suppose that it was his sympathy which gave him unbounded power of winning confidence, and as a consequence made him highly successful as a physician. He began to practise before he was twenty-one years old, and his fees during the first year paid for the keep of

two horses and a servant. On the following year his practice was large, and so continued for about sixty years, when he ceased to attend on any one. His great success as a doctor was the more remarkable as he told me that he at first hated his profession so much that if he had been sure of the smallest pittance, or if his father had given him any choice, nothing should have induced him to follow it. To the end of his life, the thought of an operation almost sickened him, and he could scarcely endure to see a person bled—a horror which he has transmitted to me."

Charles went to the day-school in Shrewsbury, when he was eight years old. "By the time I went to this day-school," he says, "my taste for natural history, and more especially for collecting, was well developed. I tried to make out the names of plants, and collected all sorts of things, shells, seals, franks, coins, and minerals. The passion for collecting, which leads a man to be a systematic naturalist, a virtuoso, or a miser, was very strong in me, and was clearly innate, as none of my sisters or brothers ever had this taste. . . .

"I must have been a very simple little fellow when I first went to the school. A boy of the name of Garnett took me into a cake-shop one day, and bought some cakes, for which he did not pay, as the shopman trusted him. When he came out I asked him why he did not pay for them, and he instantly answered, 'Why, do you not know that my uncle left a great sum of money to the town on condition that every tradesman should give whatever was wanted without payment to any one who wore his old hat and moved it in a particular manner?' and he then showed me how it was moved. He then went into another shop where he was trusted, and asked for some small article, moving his hat in the proper manner, and of course obtained it without payment.

"When we came out, he said: 'Now, if you like to go by yourself into that cake-shop (how well I remember its exact position) I will lend you my hat, and you can get whatever you like if you move the hat on your head properly.' I gladly accepted the generous offer, and went in and asked for some cakes, moved the old hat and was walking out of the shop when the shopman made a rush at me, so I dropped the cakes and ran for dear life, and was astonished by being greeted with shouts of laughter by my false friend Garnett.

"In the summer of 1818, I went to Dr. Butler's great school in Shrewsbury, and remained there for seven years, till midsummer, 1825, when I was sixteen years old. I boarded at this school, so that I had the great advantage of living the life of a true schoolboy; but as the distance was hardly more than a mile to my home, I very often ran there in the longer intervals between the callings over, and before locking up at night. This, I think, was in many ways advantageous to me, by keeping up home affections and interests. I remember, in the early part of my school life, that I often had to run very quickly to be in time, and, from being a fleet runner, was generally successful; but when in doubt I prayed earnestly to God to help me, and I well remember that I attributed my success to the prayers and not to my quick running, and marvelled how generally I was aided.

"I have heard my father and elder sister say that I had, as a very young boy, a strong taste for long, solitary walks; but what I thought about I know not. I often became quite absorbed, and once, whilst returning to school on the summit of the old fortifications round Shrewsbury, which had been converted into a public foot-path with no parapet on one side, I walked off and fell to the ground, but the height was only seven or eight

feet. Nevertheless, the number of thoughts which passed through my mind during this very short but sudden and wholly unexpected fall was astonishing, and seem hardly compatible with what physiologists have, I believe, proved about each thought requiring quite an appreciable amount of time."

As Dr. Butler's school was strictly classical, Darwin always felt that, for him, these years were nearly wasted. He read many authors, Shakespeare, Thomson's "Seasons," Byron, and Scott, but later in life, he says, lost all taste for poetry. This he greatly regretted, and said, if he were to live his life over, he would read some poetry every day. The book that most influenced him was the "Wonders of the World," which gave him a desire to travel, which was finally realized in the voyage of the *Beagle*. He did not forget his zest in collecting, at first, however, taking only such insects as he found dead, for, after consulting his sister, he "concluded that it was not right to kill insects for the sake of making a collection. From reading White's 'Selborne,' I took much pleasure in watching the habits of birds, and even made notes on the subject. In my simplicity, I remember wondering why every gentleman did not become an ornithologist.

"Towards the close of my school-life, my brother worked hard at chemistry, and made a fair laboratory, with proper apparatus, in the tool-house in the garden, and I was allowed to aid him as a servant in most of his experiments. He made all the gases and many compounds, and I read with great care several books on chemistry, such as Henry and Parkes' 'Chemical Catechism.' The subject interested me greatly, and we often used to go on working till rather late at night. This was the best part of my education at school, for it showed me practically the meaning of experimental science. The

fact that we worked at chemistry somehow got known at school, and, as it was an unprecedented fact, I was nicknamed 'Gas.' . . .

"When I left the school, I was for my age neither high nor low in it, and I believe that I was considered by all my masters and by my father as a very ordinary boy, rather below the common standard in intellect. To my deep mortification, my father once said to me: 'You care for nothing but shooting, dogs, and rat-catching, and you will be a disgrace to yourself and all your family.' But my father, who was the kindest man I ever knew, and whose memory I love with all my heart, must have been angry and somewhat unjust when he used such words."

Dr. Darwin now sent his two boys, Erasmus and Charles, to Edinburgh University. Here, Charles found the lectures "intolerably dull," all except those on chemistry by Hope. His father, evidently not being able to determine for what his son was best fitted in life, suggested his being a doctor. The youth attended the clinical wards in the hospital, but one day witnessing two operations, one upon a child, he rushed away. He says, "Nor did I attend again, for hardly any inducement would have been strong enough to make me do so; this being long before the blessed days of chloroform. The two cases fairly haunted me for many a long year."

While in Edinburgh, Charles became deeply interested in marine zoölogy, and read a paper before the Plinian Society, an association organized for the study of natural history. He also attended the meetings of the Wernerian Society, where he heard Audubon deliver some interesting lectures upon the habits of North American birds, and the Royal Society, where he saw Sir Walter Scott in the chair as president.

"I looked at him and at the whole scene," says Darwin, "with some awe and reverence, and I think it was

owing to this visit during my youth, and to my having attended the Royal Medical Society, that I felt the honor of being elected, a few years ago, an honorary member of both these societies more than any other similar honor. If I had been told at that time that I should one day have been thus honored, I declare that I should have thought it as ridiculous and improbable as if I had been told that I should be elected King of England."

During this time, Charles met Sir James Mackintosh, "the best converser," he says, "I ever listened to. I heard afterwards, with a glow of pride, that he had said, 'There is something in that young man that interests me.' . . . To hear of praise from an eminent person, though no doubt apt or certain to excite vanity, is, I think, good for a young man, as it helps to keep him in the right course."

After two years at Edinburgh, Dr. Darwin, seeing that Charles probably would never become a physician, sent him to Cambridge University, that he might prepare for the Episcopal ministry.

Of this time he says, "The three years which I spent at Cambridge were wasted, as far as the academical studies were concerned, as completely as at Edinburgh and at school. I attempted mathematics, and even went during the summer of 1828 with a private tutor (a very dull man) to Barmouth, but I got on very slowly. The work was repugnant to me, chiefly from my not being able to see any meaning in the early steps in algebra." He found great delight in Paley's "Evidences of Christianity," and his "Moral Philosophy."

At Cambridge, like Humboldt, he formed a rare friendship, which helped towards his subsequent success. Professor Henslow was an ardent scholar, a devoted Christian, and a man of most winning manners and good temper. From his great knowledge of botany, en-

tomology, chemistry, mineralogy, and geology, he became a most attractive person to young Darwin, whose especial passion seemed to be the collecting of beetles. Henslow soon became equally fond of Darwin, and the two took long walks together daily, Darwin being known as "the man who walks with Henslow."

Darwin said of this model teacher, years afterward, "He had a remarkable power of making the young feel completely at ease with him; though we were all awe-struck with the amount of his knowledge. Before I saw him, I heard one young man sum up his attainments by simply saying that he knew everything. When I reflect how immediately we felt at ease with a man older, and in every way immensely our superior, I think it was as much owing to the transparent sincerity of his character as to his kindness of heart, and, perhaps, even still more to a highly remarkable absence in him of all self-consciousness. One perceived at once that he never thought of his own varied knowledge or clear intellect, but solely of the subject in hand.

"Another charm which must have struck every one was that his manner to old and distinguished persons and to the youngest student was exactly the same; and to all he showed the same winning courtesy. He would receive with interest the most trifling observation in any branch of natural history, and, however absurd a blunder one might make, he pointed it out so clearly and kindly that one left him no way disheartened, but only determined to be more accurate the next time.

"His lectures on botany were universally popular, and as clear as daylight. So popular were they that several of the older members of the University attended successive courses. Once every week he kept open house in the evening, and all who cared for natural history attended these parties, which, by thus favoring intercom-

munication, did the same good in Cambridge, in a very pleasant manner, as the scientific societies do in London. . . . This was no small advantage to some of the young men, as it stimulated their mental activity and ambition. . . .

"During the years when I associated so much with Professor Henslow, I never once saw his temper even ruffled. He never took an ill-natured view of any one's character, though very far from blind to the foibles of others. It always struck me that his mind could not be even touched by any paltry feeling of vanity, envy, or jealousy. With all this equability of temper and remarkable benevolence, there was no insipidity of character. A man must have been blind not to have perceived that beneath this placid exterior there was a vigorous and determined will. When principles came into play, no power on earth could have turned him one hair's breadth. . . .

"Reflecting over his character with gratitude and reverence, his moral attributes rise, as they should do in the highest character, in preëminence over his intellect."

Through this noble friend, Darwin had the opportunity of taking a five years' voyage in the ship *Beagle,* as a naturalist. The bark, of two hundred and thirty-five tons, under command of Captain Fitz-Roy, was commissioned by the Government to survey Patagonia, Tierra del Fuego, the shores of Chili, Peru, and some islands in the Pacific, "and to carry a chain of chronometrical measurements round the world."

Professor Henslow knew the captain, and recommended his young friend for the position. Darwin had read Humboldt's travels eagerly, and was delighted with the prospect of a journey like this.

Dr. Darwin was opposed at first, but finally said, "if you can find any man of common sense who advises you

to go, I will give my consent." Young Darwin at once visited his uncle, Josiah Wedgwood, at Maer, who approved of the journey, and soon convinced Dr. Darwin of the wisdom of it.

The vessel sailed December 27, 1831. Though for a young man of an extremely affectionate nature the separation from family was painful, yet it was a glad day for Darwin. He had looked forward eagerly to it saying, "My second life will then commence, and it shall be as a birthday for the rest of my life," and so it proved. He said, years afterward, "The voyage of the *Beagle* has been by far the most important event in my life, and has determined my whole career."

These years were busy, earnest ones, devoted to constant labor. To his father he wrote from Bahia, or San Salvador, the following spring:

No person could imagine anything so beautiful as the ancient town of Bahia; it is fairly embosomed in a luxuriant wood of beautiful trees, and situated on a steep bank, and overlooks the calm waters of the great Bay of All Saints. The houses are white and lofty, and, from the windows being narrow and long, have a very light and elegant appearance. But the exquisite, glorious pleasure of walking amongst such flowers and such trees cannot be comprehended but by those who have experienced it. . . . I will not rapturize again, but I give myself great credit in not being crazy out of pure delight. Give my love to every soul at home. . . . I think one's affections, like other good things, flourish and increase in these tropical regions.

Again he writes from Rio de Janeiro:

Here (at Rio Macoa) I first saw a tropical forest in all its sublime grandeur—nothing but the reality can give any idea how wonderful, how magnificent the scene is. . . . I never experienced such intense delight. I formerly admired

Humboldt, I now almost adore him; he alone gives any notion of the feelings which are raised in the mind on first entering the Tropics. I am now collecting fresh-water and land animals. . . . I am at present red-hot with spiders; they are very interesting, and, if I am not mistaken, I have already taken some new genera.

Busy as he was, he was ever thinking of home, and anxious to receive letters. When they were received, he almost "cried for pleasure." He writes to his sister:

If you knew the glowing, unspeakable delight which I felt at being certain that my father and all of you were well, only four months ago, you would not grudge the labor lost in keeping up the regular series of letters.

Later he writes:

It is too delightful to think that I shall see the leaves fall and hear the robin sing next autumn at Shrewsbury. My feelings are those of a schoolboy to the smallest point; I doubt whether ever boy longed for his holidays as much as I do to see you all again.

To his "dear Henslow" he writes:

It is now some months since we have been at a civilized port; nearly all this time has been spent in the most southern part of Tierra del Fuego. . . . The Fuegans are in a more miserable state of barbarism than I had expected ever to have seen a human being. In this inclement country they are absolutely naked, and their temporary houses are like what children make in summer with boughs of trees.

Captain Fitz-Roy, on a previous voyage, had carried several natives to England, and now brought them again to their own land. "They had become," says Darwin,

"entirely European in their habits and wishes, so much so that the younger one had forgotten his own language, and their countrymen paid but very little attention to them. We built houses for them, and planted gardens, but by the time we return again on our passage round the Horn, I think it will be very doubtful how much of their property will be left unstolen."

At the Cape of Good Hope, Darwin met and dined with Sir John Herschel. For some time he lived at St. Helena, "within a stone's throw of Napoleon's tomb." He became so deeply interested in his geological investigations in South America, that he wrote his sister Susan: "I literally could hardly sleep at nights for thinking over my day's work. The scenery was so new, and so majestic; everything at an elevation of twelve thousand feet bears so different an aspect from that in a lower country."

To another sister he wrote:

I trust and believe that the time spent in this voyage, if thrown away for all other respects, will produce its full worth in Natural History; and it appears to me the doing what *little* we can to increase the general stock of knowledge is as respectable an object of life as one can in any likelihood pursue. . . . What fine opportunities for geology and for studying the infinite host of living beings! Is not this a prospect to keep up the most flagging spirit? If I was to throw it away, I don't think I should ever rest quiet in my grave.

Darwin says: "As far as I can judge of myself, I worked to the utmost during the voyage, from the mere pleasure of investigation, and from my strong desire to add a few facts to the great mass of facts in natural science. But I was also ambitious to take a fair place among scientific men." In studying the geology of St. Jago, "It then first dawned on me that I might perhaps

write a book on the geology of the various countries visited, and this made me thrill with delight. That was a memorable hour to me, and how distinctly I can call to mind the low cliff of lava beneath which I rested, with the sun glaring hot, a few strange desert plants growing near, and with living corals in the tidal pools at my feet. Later in the voyage, Fitz-Roy asked me to read some of my journal, and declared it would be worth publishing, so here was a second book in prospect!"

Darwin, stirred by the right kind of ambition, had found his life-work. It would not be in the church, as his father had fondly hoped, but the world would be his audience.

On October 5, 1836, Darwin arrived at Shrewsbury, after five years' absence. He left home a high-spirited, warm-hearted youth, fond of athletic sports, and vigorous in body. He came back with a passionate love for science, "with the habit of energetic industry and of concentrated attention," but with health impaired, which made the whole of his after-life a battle with suffering. Yet he conquered, and gave to his generation a wonderful example of the power of mind over body; of victory over obstacles.

During the voyage he was an almost constant sufferer from sea-sickness. He wrote home the last year: "It is a lucky thing for me that the voyage is drawing to its close, for I positively suffer more from sea-sickness now than three years ago."

"After perhaps an hour's work," says Admiral Stokes, "he would say to me, 'old fellow, I must take the horizontal for it,' that being the best relief position from ship motion. A stretch out on one side of the table for some time would enable him to resume his labors for a while, when he had again to lie down. It was distressing to witness this early sacrifice of Mr. Darwin's

health, who ever afterwards seriously felt the ill effects of the *Beagle's* voyage."

Admiral Mellersh says: "I think he was the only man I ever knew against whom I never heard a word said; and as people, when shut up in a ship for five years, are apt to get cross with each other, that is saying a good deal." Says another: "He was never known to be out of temper, or to say one unkind or hasty word *of* or *to* any one."

This lovely spirit, which so endeared him to everybody, Darwin kept through life,—a spirit which sheds a halo around every book he wrote, and makes him worthy the admiration and honor of every young man. Many persons have the gift of writing books, but comparatively few persons have the great gift of self-control.

After a brief visit with his family, Darwin hastened to Cambridge, to prepare his "Journal of Travels." He had learned on the *Beagle* that "a man who dares to waste one hour of time has not discovered the value of life." After three months of hard work, he went to London, where he finished the "Journal," and began working on his "Zoölogy of the Voyage of the Beagle," and his "Geological Observations." He said at this time: "I have nothing to wish for, excepting stronger health to go on with the subjects to which I have joyfully determined to devote my life."

For three years and eight months he worked untiringly. He wrote Henslow:

I fear the Geology will take me a great deal of time; I was looking over one set of notes, and the quantity I found I had to read for that one place was frightful. If I live till I am eighty years old I shall not cease to marvel at finding myself an author. In the summer before I started, if any one had told me that I should have been an angel by

this time, I should have thought it an equal impossibility. This marvellous transformation is all owing to you.

Darwin and Lyell now became very intimate friends. "I am coming into your way, of only working about two hours at a spell," he writes to Lyell; "I then go out and do my business in the streets, return and set to work again, and thus make two separate days out of one." Of Lyell he said: "One of his chief characteristics was his sympathy with the work of others. . . . The science of geology is enormously indebted to Lyell—more so, as I believe, than to any other man who ever lived."

The "Journal" was published in 1839. January twenty-nine of this year, Mr. Darwin, now thirty years of age, was married to his cousin, Emma Wedgwood, daughter of Josiah Wedgwood of Maer, and granddaughter of the founder of the potteries of Etruria. The extreme happiness of his married life proved the wisdom of his choice. He said in after years, "No one can be too kind to my dear wife, who is worth her weight in gold many times over."

They lived at Number 12 Upper Gower Street, as he wrote a college mate, "a life of extreme quietness. . . . We have given up all parties, for they agree with neither of us; and if one is quiet in London, there is nothing like its quietness."

In 1842, his "Structure and Distribution of Coral Reefs" was published, a book which cost him, he says, "Twenty months of hard work, as I had to read every work on the islands of the Pacific, and to consult many charts." Of this book, Professor Geikie says: "This well known treatise, the most original of all its author's geological memoirs, has become one of the classics of geological literature. The origin of those remarkable rings of coral-rock in mid-ocean has given rise to much

speculation, but no satisfactory solution of the problem has been proposed. After visiting many of them, and examining also coral reefs that fringe islands and continents, he offered a theory which, for simplicity and grandeur, strikes every reader with astonishment. . . . No more admirable example of scientific method was ever given to the world, and, even if he had written nothing else, this treatise alone would have placed Darwin in the very front of investigators of nature."

Lyell wrote to Darwin concerning this book: "It is all true, but do not flatter yourself that you will be believed till you are growing bald, like me, with hard work and vexation at the incredulity of the world."

Darwin's next work, on the "Volcanic Islands Visited during the Voyage of the Beagle," was published in 1844. This book, he said, "cost me eighteen months." His third geological book, "Geological Observations on South America," was published in 1846.

Meantime, tired of smoky London, Darwin purchased a home in Down, a retired village five or six hundred feet above the sea. The house was a square brick building, of three stories, vine-covered, in the midst of eighteen acres. "Its chief merit," Darwin writes to a friend, "is its extreme rurality. I think I was never in a more perfectly quiet country." Here, for forty years, Darwin lived the isolated life of a student, producing the books that made him the most noted scientist of his century. Of these years, Mr. Darwin said: "Few persons can have lived a more retired life than we have done. Besides short visits to the houses of relations, and occasionally to the seaside or elsewhere, we have gone nowhere. During the first part of our residence we went a little into society, and received a few friends here; but my health almost always suffered from the excitement.

. . . I have, therefore, been compelled for many years to give up all dinner parties. . . . From the same cause I have been able to invite here very few scientific acquaintances. My chief enjoyment and sole employment throughout life has been scientific work; and the excitement from such work makes me for the time forget, or drives quite away, my daily discomfort."

At Down, Darwin worked for eight years on two large volumes concerning cirripedia (barnacles), describing all the known living species; the extinct species, or fossil cirripedes, were in two smaller volumes. The first books were published by the Ray Society, between 1851 and 1854; the others by the Palæontographical Society. About two years out of the eight were lost through illness. Sometimes he became half discouraged. He wrote a friend, "I have been so steadily going downhill, I cannot help doubting whether I can ever crawl a little uphill again. Unless I can, enough to work a little, I hope my life may be very short, for to lie on a sofa all day and do nothing but give trouble to the best and kindest of wives and good, dear children is dreadful."

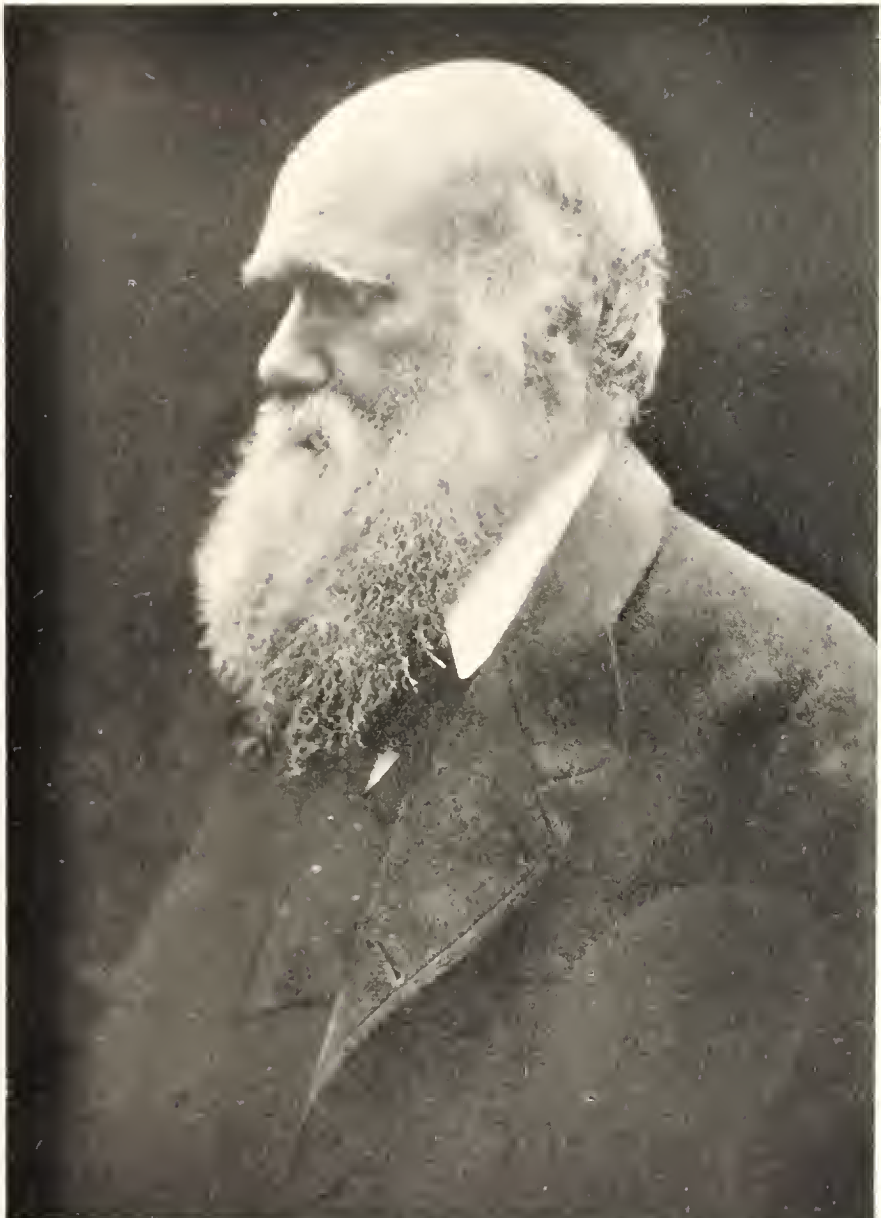
Darwin doubted, in after life, "whether the work was worth the consumption of so much time," but Professor Huxley thinks he "never did a wiser thing than when he devoted himself to the years of patient toil which the cirriped-book cost him. . . . The value of the cirriped monograph lies not merely in the fact that it is a very admirable piece of work, and constituted a great addition to positive knowledge, but still more in the circumstance that it was a piece of critical self-discipline, the effect of which manifested itself in everything he wrote afterwards, and saved him from endless errors of detail." Darwin's patient labor is shown by his working "for the last half-month, daily, in dissecting a little animal

about the size of a pin's head, from the Chonos archipelago, and I could spend another month, and daily see more beautiful structure."

During these years from 1846 to 1854, death had twice disturbed the quiet life at Down. In 1849, Dr. Darwin, died, and his son Charles was so ill that he could not attend the funeral. In 1851, Annie Darwin died, at the age of ten, after a brief illness. "She was," said Darwin, "my favorite child; her cordiality, openness, buoyant joyousness, and strong affections made her most lovable. . . . When quite a baby, this [strong affection] showed itself in never being easy without touching her mother when in bed with her; and quite lately she would, when poorly, fondle for any length of time one of her mother's arms. . . . She would at almost any time spend half an hour in arranging my hair, 'making it,' as she called it, 'beautiful,' or in smoothing, the poor, dear darling, my collar or cuffs—in short, in fondling me. . . . Her whole mind was pure and transparent. One felt one knew her thoroughly and could trust her. I always thought that, come what might, we should have had, in our old age, at least one loving soul which nothing could have changed.

"All her movements were vigorous, active, and usually graceful. When going round the Sandwalk with me, although I walked fast, yet she often used to go before, pirouetting in the most elegant way, her dear face bright all the time with the sweetest smiles. Occasionally she had a pretty coquettish manner towards me, the memory of which is charming. . . .

"In the last short illness her conduct, in simple truth, was angelic. She never once complained; never became fretful; was ever considerate of others, and was thankful in the most gentle, pathetic manner for everything done for her. When so exhausted that she could hardly speak,



CHARLES ROBERT DARWIN
From a photograph

she praised everything that was given her, and said some tea 'was beautifully good.' When I gave her some water, she said, 'I quite thank you;' and these, I believe, were the last precious words ever addressed by her dear lips to me."

Such consideration and politeness she naturally inherited. Francis Darwin says in his delightful life of his father, "He always spoke to servants with politeness, using the expression, 'Would you be so good,' in asking for anything. In business matters he was equally courteous. His solicitor, who had never met him, said, 'Everything I did was right, and everything was profusely thanked for.'" Of the drawings made by his children, he would say, "Michael Angelo is nothing to it!" but he always looked carefully at the work and kindly pointed out mistakes.

"He received," says his son, "many letters from foolish, unscrupulous people, and all of these received replies. He used to say that if he did not answer them, he had it on his conscience afterwards, and, no doubt, it was in great measure the courtesy with which he answered every one which produced the universal and widespread sense of his kindness of nature which was so evident on his death."

In November, 1853, Darwin received the Royal Society's Medal. He was gratified, finding it "a pleasant little stimulus. When work goes badly, and one ruminates that all is vanity, it is pleasant to have some tangible proof that others have thought something of one's labors."

November 24, 1859, when Darwin was fifty, his great work, "Origin of Species by means of Natural Selection, or the Preservation of Favored Races in the Struggle for Life," was published. For twenty years he had been making experiments with plants and animals, and filling

his note-books with facts. To his old classmate, Fox, he writes asking that the boys in his school gather lizards' eggs, as well as those of snakes. "My object is," he says, "to see whether such eggs will float on sea-water, and whether they will keep alive thus floating for a month or two in my cellar. I am trying experiments on transportation of all organic beings that I can; and lizards are found on every island, and therefore I am very anxious to see whether their eggs stand sea-water." Again he writes, asking Fox for ducklings and dorkings; "The chief point which I am and have been for years very curious about is to ascertain whether the *young* of our domestic breeds differ as much from each other as do their parents, and I have no faith in anything short of actual measurement and the Rule of Three. . . . I have got my fan-tails and pouters in a grand cage and pigeon-house, and they are a decided amusement to me, and delight to H."

Of this book, Darwin himself says: "I worked on true Baconian principles, and without any theory—collected facts on a wholesale scale, more especially with respect to domesticated productions, by printed inquiries, by conversation with skilful breeders and gardeners, and by extensive reading. When I see the list of books of all kinds which I read and abstracted, including whole series of Journals and Transactions, I am surprised at my industry. I soon perceived that selection was the keystone of man's success in making useful races of animals and plants. . . .

"In October, 1838, that is, fifteen months after I had begun my systematic inquiry, I happened to read 'Malthus on Population,' and, being well prepared to appreciate the struggle for existence which everywhere goes on, from long continued observation of the habits of animals and plants, it at once struck me that under these circum-

stances favorable variations would tend to be preserved, and unfavorable ones to be destroyed. The result of this would be the formation of new species. . . . But at that time I overlooked one problem of great importance. . . . This problem is the tendency in organic beings descended from the same stock to diverge in character as they become modified. That they have diverged greatly is obvious from the manner in which species of all kinds can be classed under genera, genera under families, families under sub-orders, and so forth. . . . The solution, as I believe, is that the modified offspring of all dominant and increasing forms tend to become adapted to many and highly diversified places in the economy of nature."

The book was written slowly, each chapter requiring at least three months. When the "Origin of Species"—which had reached its thirty-third thousand in 1888—was published, it created the most profound sensation throughout the thinking world. Heretofore, most men of science had believed that each species had been separately created by the Almighty,—that species were immutable, unchanging.

Mr. Darwin, by twenty years of study, proved to his own mind, and now to most of the world, that there has been a gradual evolution, through unnumbered ages, of one form of animal life from another. He said, "Probably all the organic beings which have ever lived on the earth have descended from some one primordial form, into which life was first breathed."

The theory of evolution was not original with Darwin. Lamarck, in 1801, published his "Organization of Living Bodies," in which he stated his belief "that nature, in all the long ages during which the world has existed, may have produced the different kinds of plants and animals by gradually enlarging one part and diminishing another

to suit the wants of each." Geoffroy Saint-Hilaire, Goethe, Dr. Erasmus Darwin, the grandfather of Charles, all believed that species are descended from other species, and in various ways improved.

Some of the reasons for the belief in evolution are so simply and clearly stated by Arabella B. Buckley, in her "Short History of Natural Science," that I quote her words:——

"All the Animals of each class are formed on the same plan. . . .

"Why should the animals of one class (such as the vertebrate or back-boned class) be formed all on one plan, even to the most minute bones; so that the wing of a bat, the front leg of a horse, the hand of a man, and the flapper of a porpoise, are all made of the same bones, which have either grown together, or lengthened and spread apart, according to the purpose they serve? And, more curious still, why should some animals have parts which are of no use to them, but only seem to be there because other animals of the same class also have them? Thus the whale has teeth like the other mammalia, but they never pierce through the gum; and the boa-constrictor has the beginnings of hind legs, hidden under its skin, though they never grow out. Here, again, it seems extraordinary, if a boa-constrictor and a whale were created separately, that they should be made with organs which are quite useless; while, on the other hand, if they were descended from the same ancestor, as other reptiles and mammalia who have teeth and hind legs, they might be supposed to have inherited these organs. . . .

"Embryos of animals alike in Structure.

"Another still more remarkable fact was that pointed out by Von Baer, that the higher animals, such as quadrupeds, before they are perfectly formed, cannot be distinguished from the embryos of other and lower animals,

such as fish and reptiles. If animals were created separately, why should a dog begin like a fish, a lizard, and a bird, and have at first parts which it loses as it grows into its own peculiar form?

"Living animals of a country agree with the fossil ones. . . .

"We know that certain animals are only found in particular countries; kangaroos and pouched animals, for example, in Australia, and sloths and armadillos in South America. Now, it is remarkable that all the fossil quadrupeds in Australia are also pouched animals, though they are of different kinds and larger in size than those now living; and in the same way different species of sloth and armadillos are found fossil in South America; while in the rocks of Europe fossil mammalia are found, only slightly different from those which are living there now." It seems natural to conclude that the living have descended from the fossils."

The study of the rocks has produced other "missing links" in the succession of animal life. Professor Huxley, in some lectures given in New York in 1876, described the Hesperornis, found in the western rocks,—a huge bird, five or six feet in length, with teeth like a reptile. In England a fossil reptile has been found, the Archæopteryx, having a reptile-like tail, with a fringe of feathers on each side, and teeth, "occupying a midway place between a bird and a reptile." Flying reptiles have been found, and reptiles which walked on their hind legs. Those who have visited Yale and Amherst Colleges must have seen the huge bird-tracks or reptile foot-prints taken from the rocks in the Connecticut valley.

Professor Huxley showed the probable descent of the horse with its hoofed foot from the extinct three-toed Hipparion of Europe, and that from the four-toed Orohippus of the Eocene formation. He declared it

probable that a five-toed horse would be found, and Professor Marsh, in the West, has found the Eohippus, corresponding very nearly to Professor Huxley's description.

The question among naturalists was, "How can plants and animals have become thus changed?" Darwin showed how it was possible to effect most of these changes by "natural selection," or the choosing of the best to survive in the struggle for existence. As man by grafting secures the finest fruit, and by care in animal life the swiftest horses for speed as well as the strongest for labor, so nature selects her best for the higher development of the race.

Darwin says, "There is no exception to the rule that every organic being naturally increases at so high a rate that, if not destroyed, the earth would soon be covered by the progeny of a single pair. Even slow-breeding man has doubled in twenty-five years, and, at this rate, in less than a thousand years there would literally not be standing-room for his progeny. . . . The elephant is reckoned the slowest breeder of all known animals; it will be safest to assume that it begins breeding when thirty years old, and goes on breeding till ninety years old, bringing forth six young in the interval, and surviving till one hundred years old; if this be so, after a period of from 740 to 750 years, there would be nearly nineteen million elephants alive, descended from the first pair."

In various ways the weakest are destroyed. Darwin, on a piece of ground three feet long and two wide, says, "I marked all the seedlings of our native weeds as they came up, and, out of 357, no less than 295 were destroyed, chiefly by slugs and insects."

He gives this interesting instance of the struggle for existence. "I find from experiments that humble-bees

are almost indispensable to the fertilization of the heart's-ease, for other bees do not visit this flower. . . . Humble-bees alone visit red clover, as other bees cannot reach the nectar. . . . Hence we may infer as highly probable that, if the whole genus of humble-bees became extinct or very rare in England, the heart's-ease and red clover would become very rare, or wholly disappear. The number of humble-bees in any district depends in a great measure upon the number of field-mice, which destroy their combs and nests; the number of mice is largely dependent, as every one knows, on the number of cats." Hence, as Mr. Darwin shows, the frequency of certain flowers in a district may depend upon the number of cats!

Darwin showed, by most interesting experiments with pigeons, that the various breeds come from the wild rock-pigeon; that dogs are descended, probably, from the wolf; that different varieties can be produced and perpetuated under changing conditions of life; that species are only well marked and permanent varieties. He showed how organs can be changed by use or disuse; such as, the erect ears of wild animals become drooping under domestication; or moles have only rudimentary eyes, covered with skin or fur, because not needed for sight.

In the "Origin of Species," the theory of evolution received proof which was so nearly incontrovertible that the subject was brought prominently before the world as never before. Mr. Alfred Russell Wallace, an able scientist, came to the same conclusion as Darwin in regard to the power of "Natural Selection," and published, at the same time as the "Origin," an essay "On the Tendency of Varieties to depart indefinitely from the Original Type."

At once Darwin was attacked from every quarter. Probably not since Galileo showed that the earth moves

round the sun has a man been so censured and persecuted for his opinions as was Darwin. He was declared atheistic, unsettling the Christian belief, and opposed to the teachings of the Bible. Professor Asa Gray of Cambridge, Mass., a devoted Christian and able scientist, defended and explained Darwin's views, now published in "Darwiniana," claiming that the doctrine of evolution is in no wise opposed to the power and goodness of the Almighty, and quotes Charles Kingsley's words: "We know of old that God was so wise that he could make all things; but behold, he is so much wiser than even that, that he can make all things make themselves." Kingsley wrote Darwin:

I have gradually learnt to see that it is just as noble a conception of Deity to believe that he created primal forms capable of self-development into all forms needful *pro tempore* and *pro loco,* as to believe that he required a fresh act of intervention to supply the *lacunas* which he himself had made. I question whether the former be not the loftier thought.

Gray believed that "to do any work by an instrument must require, and therefore presuppose, the exertion rather of more than of less power than to do it directly." Darwin said, "There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms, most beautiful and most wonderful, have been and are being evolved." Darwin always felt grateful to Asa Gray for his defence. He wrote him:

I declare that you know my book as well as I do myself; and bring to the question new lines of illustration and argu-

ment, in a manner which excites my astonishment and almost my envy! . . . I said, in a former letter, that you were a lawyer, but I made a gross mistake; I am sure that you are a poet. No, I will tell you what you are, a hybrid, a complex cross of lawyer, poet, naturalist, and theologian!

Darwin wisely made no reply to his critics. He said, years later: "My views have often been grossly misrepresented, bitterly opposed and ridiculed, but this has been generally done, as I believe, in good faith. On the whole, I do not doubt that my works have been over and over again greatly overpraised. I rejoice that I have avoided controversies, and this I owe to Lyell, who, many years ago, in reference to my geological works, strongly advised me never to get entangled in a controversy, as it rarely did any good, and caused a miserable loss of time and temper.

"Whenever I have found out that I have blundered, or that my work has been imperfect, and when I have been contemptuously criticised, and even when I have been overpraised, so that I have felt mortified, it has been my greatest comfort to say hundreds of times to myself, 'that I have worked as hard and as well as I could, and no man can do more than this.' "

The "Origin" has been translated into French, German, Italian, Dutch, Russian, Swedish, and many other languages. Huxley says of it, "Even a cursory glance at the history of the biological sciences during the last quarter of a century is sufficient to justify the assertion that the most potent instrument for the extension of the realm of natural knowledge which has come into men's hands since the publication of Newton's 'Principia' is Darwin's 'Origin of Species.' "

The year after the "Origin" was published, Darwin began arranging his notes for his two large volumes, "Variation of Animals and Plants under Domestication,"

which, however, were not published till 1868. On these two books he spent over four years. They are a wonderful collection of facts, gathered from books and from his own marvellous experiments and observations, confirming and illustrating the law of "Natural Selection" given in the "Origin."

Darwin had already received the Copley medal of the Royal Society, the greatest honor a scientific man can receive in England, and the Prussian Order "Pour le Mérite," founded by Frederick II. The order consists of thirty German members and a few distinguished foreigners. In 1862 the "Fertilization of Orchids" was published, which required ten months of labor. In this work Darwin took the utmost delight. He wrote to a friend who had sent him some of these flowers:

> It is impossible to thank you enough. I was almost mad at the wealth of Orchids. . . . I never was more interested in any subject in my life than in this of Orchids. The peculiarities of the flowers therein described, as Darwin says, transcend in an incomparable manner the contrivances and adaptations which the most fertile imagination of man could invent.

In the "Origin" he describes an orchid which "has part of its labellum or lower lip hollowed out into a great bucket, into which drops of almost pure water continually fall from two secreting horns which stand above it; and when the bucket is half full the water overflows by a spout on one side. The basal part of the labellum stands over the bucket, and is itself hollowed out into a sort of chamber with two lateral entrances; within this chamber there are curious fleshy ridges. The most ingenious man, if he had not witnessed what takes place, could never have imagined what purpose all these parts serve. But Dr. Crüger saw crowds of large humble-bees visiting the

gigantic flowers of this orchid, not in order to suck nectar, but to gnaw off the ridges within the chamber above the bucket; in doing this they frequently pushed each other into the bucket, and, their wings being thus wetted, they could not fly away, but were compelled to crawl out through the passage formed by the spout or overflow. . . . The passage is narrow, and is roofed over by the column, so that a bee, in forcing its way out, first rubs its back against the viscid stigma and then against the viscid glands of the pollen-masses. The pollen-masses are thus glued to the back of the bee which first happens to crawl out through the passage of a lately expanded flower, and are thus carried away. . . .

"When the bee, thus provided, flies to another flower, or to the same flower a second time, and is pushed by its comrades into the bucket and then crawls out by the passage, the pollen-mass necessarily comes first into contact with the viscid stigma, and adheres to it, and the flower is fertilized. Now at last we see the full use of every part of the flower; of the water-secreting horns, of the bucket half full of water, which prevents the bees from flying away, and forces them to crawl out through the spout, and rub against the properly placed viscid pollen-masses and the viscid stigma."

Darwin said: "The Botanists praise my Orchid-book to the skies. . . . There is a superb, but, I fear, exaggerated, review in the 'London Review.' But I have not been a fool, as I thought I was, to publish; for Asa Gray, about the most competent judge in the world, thinks almost as highly of the book as does the 'London Review.'"

Darwin wrote several other books on plants. "The Movements and Habits of Climbing Plants" was published in 1875; "Insectivorous Plants," in 1875; "Effects of Cross and Self-Fertilization," in 1876; "The different Forms of Flowers on Plants of the Same Species," in

1877; "The Power of Movement in Plants," in 1880.

When writing his "Different Forms of Flowers," he said, "I am all on fire at the work;" and of "Insectivorous Plants," "I have been working like a madman at Drosera. Here is a fact for you which is certain as you stand where you are, though you won't believe it, that a bit of hair, 1/78000 of one grain in weight, placed on gland, will cause *one* of the gland-bearing hairs of Drosera to curve inwards, and will alter the condition of the contents of every cell in the foot-stalk of the gland."

But he was growing tired with his constant and multifarious labors. He wrote to Hooker:

> You ask about my book, and all that I can say is that I am ready to commit suicide; I thought it was decently written, but find so much wants rewriting that it will not be ready to go to the printers for two months, and will then make a confoundedly big book. Murray will say that it is no use publishing in the middle of summer, so I do not know what will be the upshot; but I begin to think that every one who publishes a book is a fool.

In 1871 the "Descent of Man" was published. He worked on this book three years, and he wrote to his friend, Sir J. D. Hooker, that it had "half killed" him. For the first edition Darwin received over seven thousand dollars. It had an immense circulation in England and America, and created a furor in Germany.

Darwin believed "that man is descended from a hairy quadruped, furnished with a tail and pointed ears, probably arboreal in its habits, and an inhabitant of the Old World. This creature, if its whole structure had been examined by a naturalist, would have been classed among the quadrumana, as surely as would the common and still more ancient progenitor of the Old and New World monkeys.

"The quadrumana and all the higher mammals are probably derived from an ancient marsupial animal, and this, through a long line of diversified forms, either from some reptile-like or some amphibian-like creature, and this again from some fishlike animal. In the dim obscurity of the past, we can see that the early progenitor of all the vertebrata must have been an aquatic animal, provided with branchiæ, with the two sexes united in the same individual, and with the most important organs of the body (such as the brain and heart) imperfectly developed. This animal seems to have been more like the larvæ of our existing marine Ascidians than any known form."

Darwin received much abuse and much ridicule for his views. Mr. James D. Hague tells in "Harper's Magazine" of a visit paid to the great scientist, when a picture in the "Hornet" was shown; the body of a gorilla, with the head of Darwin. The latter laughed and said, "The head is cleverly done, but the gorilla is bad; too much chest; it couldn't be like that."

The "Descent of Man" shows the widest research, and is a storehouse of most interesting facts. "Sexual Selection" shows some of the most remarkable provisions of nature, and is as interesting as any novel. This book, like the "Origin," has been translated into various languages.

In 1872 "The Expression of the Emotions in Man and Animals" was published. Over five thousand copies were sold on the day of publication. It was begun at the birth of his first child, thirty-three years before. He says, "I at once commenced to make notes on the first dawn of the various expressions which he exhibited, for I felt convinced, even at this early period, that the most complex and fine shades of expression must all have had a gradual and natural origin." He wrote to a col-

lege friend regarding this baby: "He is so charming that I cannot pretend to any modesty. I defy anybody to flatter us on our baby, for I defy any one to say anything in its praise of which we are not fully conscious. . . . I had not the smallest conception there was so much in a five-month baby. You will perceive by this that I have a fine degree of paternal fervor."

In 1881, "The Formation of Vegetable Mould, through the Action of Worms, with Observations on their Habits," was published. "Fragments of burnt marl, cinders, etc., which had been thickly strewed over the surface of several meadows were found, after a few years, lying at a depth of some inches beneath the turf, but still forming a layer." Ascertaining that this was the work of worms, Darwin made a study of their structure, habits, and work, in his garden, his fields, and in pots of earth kept in his study. The intelligence of worms, the construction of their burrows, and the amount of labor they can perform, are described in a most entertaining manner. Over fifty thousand worms are found in a single acre of land, or about three hundred and fifty-six pounds. "In many parts of England a weight of more than ten tons of dry earth annually passes through their bodies, and is brought to the surface, on each acre of land. . . . Worms prepare the ground in an excellent manner for the growth of fibrous-rooted plants and for seedlings of all kinds. They periodically expose the mould to the air, and sift it so that no stones larger than the particles which they can swallow are left in it. They mingle the whole intimately together, like a gardener who prepares fine soil for his choicest plants. . . . The plough is one of the most ancient and most valuable of man's inventions; but long before he existed the land was in fact regularly ploughed, and still continues to be thus ploughed, by earthworms. It may be doubted whether there are

many other animals which have played so important a part in the history of the world as have these lowly organized creatures."

In three years eighty-five hundred copies of the "Earthworms" were sold.

Mr. Darwin was now seventy-two years old. Already many honors had come to him, after the severe and bitter censure. In 1877, he received the degree of LL. D. from Cambridge University. In 1878, he was elected a corresponding member of the French Institute, and of the Berlin Academy of Sciences. In 1879, he received the Baly Medal of the Royal College of Physicians. In 1879, from the Royal Academy of Turin, the *Bressa* Prize of twelve thousand francs. He valued highly two photographic albums sent from Germany and Holland; one containing the pictures of one hundred and fifty-four noted scientific men; the other, of two hundred and seventeen lovers of natural science in the Netherlands. He wrote in thanks: "I am well aware that my books could never have been written, and would not have made any impression on the public mind, had not an immense amount of material been collected by a long series of admirable observers; and it is to them that honor is chiefly due. I suppose that every worker at science occasionally feels depressed, and doubts whether what he has published has been worth the labor which it has cost him, but for the few remaining years of my life, whenever I want cheering, I will look at the portraits of my distinguished co-workers in the field of science, and remember their generous sympathy."

He was made a member of more than seventy of the learned societies of the world; in America, Austria, India, Belgium, Denmark, France, Germany, Holland, Italy, Portugal, Russia, Spain, Sweden, Switzerland and elsewhere.

Darwin's work was now almost over. His dear friend Lyell had gone before him, of whom he said, "I never forget that almost everything which I have done in science I owe to the study of his great works." His brother Erasmus, to whom he was tenderly attached, died in 1881. In the spring of 1882 he was unable to work continuously as usual, and suffered from pain about the heart. On the night of April 18, he had a severe attack and fainted. When he was restored to consciousness, he said, "I am not the least afraid to die." He died the next day, April 19.

Darwin died as he had lived, with a heart overflowing with sympathy and tenderness. He said, "I feel no remorse from having committed any great sin, but have often and often regretted that I have not done more direct good to my fellow-creatures."

In his home life he was singularly blest. His son says, "No one except my mother knows the full amount of suffering he endured, or the full amount of his wonderful patience. For all the latter years of his life she never left him for a night; and her days were so planned that all his resting hours might be shared with her. She shielded him from every avoidable annoyance, and omitted nothing that might save him trouble, or prevent him becoming overtired, or that might alleviate the many discomforts of his ill-health. I hesitate to speak thus freely of a thing so sacred as the life-long devotion which prompted all this constant and tender care. But it is . . . a principal feature of his life that for nearly forty years he never knew one day of the health of ordinary men, and that thus his life was one long struggle against the weariness and strain of sickness." And yet he accomplished all his wonderful work!

"In his relationship towards my mother, his tender and sympathetic nature was shown in its most beautiful aspect. In her presence he found his happiness, and through

her his life—which might have been overshadowed by gloom—became one of content and quiet gladness."

He was the idol of his children, who used "to bribe him with sixpence to come and play in working hours." "We all knew the sacredness of working time," says Mr. Darwin's daughter, "but that any one should resist sixpence seemed an impossibility. . . . Another mark of his unbounded patience was the way in which we were suffered to make raids into the study when we had an absolute need of sticking-plaster, string, pins, scissors, stamps, foot-rule, or hammer. These and other such necessaries were always to be found in the study, and it was the only place where this was a certainty. We used to feel it wrong to go in during work-time; still, when the necessity was great we did so. I remember his patient look when he said once, 'Don't you think you could not come in again; I have been interrupted very often?' . . . He cared for all our pursuits and interests, and lived our lives with us in a way that very few fathers do."

His son says: "The way he brought us up is shown by a little story about my brother Leonard, which my father was fond of telling. He came into the drawing-room, and found Leonard dancing about on the sofa, which was forbidden, for the sake of the springs, and said, 'Oh, Lenny, Lenny, that's against all rules!' and received for answer, 'Then, I think you'd better go out of the room.' I do not believe he ever spoke an angry word to any of his children in his life; but I am certain that it never entered our heads to disobey him. . . . How often, when a man, I have wished, when my father was behind my chair, that he would pass his hand over my hair, as he used to do when I was a boy. He allowed his grown-up children to laugh with and at him, and was, generally speaking, on terms of perfect equality with us."

He was very fond of flowers, and also of dogs. When he had been absent from home, on his return his white fox-terrier, Polly, "would get wild with excitement, panting, squeaking, rushing round the room, and jumping on and off the chairs; and he used to stoop down, pressing her face to his, letting her lick him, and speaking to her with a peculiarly tender, caressing voice."

He was very tender-hearted. A friend who often visited at Down told me that Mrs. Darwin one day urged her husband to punish the little dog for some wrongdoing. He took the animal tenderly in his arms and carried her out-of-doors, patting her gently on the head. "Why, Charles," remonstrated the wife, "she did not feel it." He replied, "I could do no more."

"The remembrance of screams or other sounds heard in Brazil," says Francis Darwin, "when he was powerless to interfere with what he believed to be the torture of a slave, haunted him for years, especially at night. In smaller matters, when he could interfere, he did so vigorously. He returned one day from his walk pale and faint from having seen a horse ill-used, and from the agitation of violently remonstrating with the man. On another occasion he saw a horse-breaker teaching his son to ride. The little boy was frightened, and the man was rough. My father stopped, and, jumping out of the carriage, reproved the man in no measured terms. . . .

"A visitor, driving from Orpington to Down, told the man to go faster. 'Why,' said the driver, 'if I had whipped the horse *this* much driving Mr. Darwin, he would have got out of the carriage and abused me well.'"

His manner was bright and animated, and his face glowed in conversation. He enjoyed fun, had a merry, ringing laugh, and a happy way of turning things. He said once, "Gray [Asa Gray of Harvard College] often takes me to task for making hasty generalizations; but

the last time he was here talking that way, I said to him, 'Now, Gray, I have one more generalization to make, which is not hasty; and that is, the Americans are the most delightful people I know.' "

"He was particularly charming when 'chaffing' any one," says his son, "and in high spirits over it. His manner at such times was light-hearted and boyish, and his refinement of nature came out most strongly. So, when he was talking to a lady who pleased and amused him, the combination of raillery and deference in his manner was delightful to see. When my father had several guests, he managed them well, getting a talk with each, or bringing two or three together round his chair. . . .

"My father much enjoyed wandering slowly in the garden with my mother or some of his children, or making one of a party sitting out on a bench on the lawn; he generally sat, however, on the grass, and I remember him often lying under one of the big lime-trees, with his head on the green mound at its foot."

He had great perseverance in his work, and used often to say, "It's dogged as does it;" and "Saving the minutes is the way to get work done." It was his habit to rise early in the morning, and after breakfast work from eight to half-past nine, and then read his letters. At ten or half-past, he went back to his work till twelve. After exercise in the "Sandwalk," a narrow strip of land, one and a half acres in extent, with a gravel walk round it, planted with a variety of trees, in which he watched the birds and squirrels, he lunched and read his newspaper. After this he wrote letters, and about three o'clock rested for a time on the sofa, some of his family reading to him, often a novel,—the work of Walter Scott, George Eliot, Miss Austen, or others. At four he walked again, worked from half-past four till half-past five, dined, and

usually spent his evenings, after a game of backgammon with his wife, or hearing her play on the piano, in reading scientific books. Conversation in the evening usually spoiled his rest for the night, but he could do a great amount of work if he kept to his regular routine. In each book, as he read it, he marked passages bearing on his work. In reading a book or pamphlet, he made pencil lines at the side of the page, often adding short remarks, and at the end made a list of the pages marked.

Darwin said of himself: "At no time am I a quick thinker or writer; whatever I have done in science has solely been by long pondering, patience, and industry. . . . I think that I am superior to the common run of men in noticing things which easily escape attention, and in observing them carefully. My industry has been nearly as great as it could have been in the observation and collection of facts. What is far more important, my love of natural science has been steady and ardent.

"This pure love has, however, been much aided by the ambition to be esteemed by my fellow-naturalists. From my early youth I have had the strongest desire to understand or explain whatever I observed; that is, to group all facts under some general laws. . . . My habits are methodical, and this has been of not a little use for my particular line of work. Lastly, I have had ample leisure from not having to earn my own bread. Even ill-health, though it has annihilated several years of my life, has saved me from the distractions of society and amusement."

Darwin's life is a most interesting study. That a boy who seemed in youth to have no special fondness for books, but an especial delight in collecting beetles; who appeared unfitted either for medicine or the church, should come to such a renowned manhood, is remarkable. His

perseverance, his industry, his thought, his gentleness, his sunny nature in the midst of suffering, are delightful to contemplate. His books and teachings will be an enduring monument.

LOUIS PASTEUR

The science of chemistry is the key to our present day medical progress, and for the initial use of this key we are indebted to Louis Pasteur, whose death occurred only a generation ago. He is known primarily as the discoverer of bacteria as the cause of contagious diseases and of antitoxin as their cure. Behind him stretches a long period of groping in the dark, when to use an old and bitter saying, "the doctors put medicines of which they knew little into bodies of which they knew nothing." Today, thanks to Pasteur and his able following, chemistry has proved that the body of every living thing is a chemical laboratory wherein each breath is accompanied by minute chemical reactions of endless variety and complexity. We know that the microbes which destroy us, do so by creating deadly poisons from the various compounds which they find in our systems, and that the anti-bodies which Nature creates to combat the poison-makers are but other compounds brought valiantly to the fore to check the ravages.

Familiarity with these various anti-bodies and the substances which under certain conditions will increase their force and add to their virulence is a triumph which chemistry is daily wresting, and often with the most miraculous results in train. For example, a cure for African sleeping sickness promises to make half a continent habitable; the discovery of certain pure acids in chaulmoogra oil makes probable the eventual wiping out of leprosy in the climes to which it is addicted; the isolation of the pneumonia germ together with a specific—a

derivative of quinine—which kills them readily in the glass tube means, shortly it is hoped, the saving of hundreds of thousands of lives yearly from this great world-wide plague. Further instances might be cited without number, but they are unnecessary in showing the honor and gratitude due to Louis Pasteur—a teacher of chemistry, not a physician—as the great pioneer and leader in the world movement to save and enrich human life.

Like Faraday, Louis Pasteur was of humble origin. His father, Jean Pasteur, and the heads of the family for one or two generations before him, followed the tanner's trade. His mother, Jeanne Etiennette Roqui, was a gardener's daughter, and their union was the attraction of opposites, with far greater domestic happiness than usually results from such marriages. The husband was "reserved, almost secretive;" the wife "active, full of imagination and ready enthusiasm." Louis, born December 27, 1822, was the third child in a family of five, and sturdily marked with a devotion to duty and high ideals which later counted heavily in his chosen career.

As a boy we are told that he was in no wise singled out as a bright child. Indeed, the general impression is that he was only "a good average pupil," perhaps a bit slow. But the master, realizing that there are varieties of slowness, looked beneath the surface, and satisfied himself that the lad's hesitation was not lack of perception, but the desire for certainty: "He never affirmed anything of which he was not absolutely sure." This seemed a very desirable trait, and the professor spent no little time in drawing the boy out, and stimulating him to go forward. "You should enter École Normale,"[1] he said, "and fit yourself for a life of hard work for the good of others. You have no little artistic ability, and, too,

[1] A famous French training college.

you are of a scientific bent: you could go far in either of these fields."

But the father was in no mind to have his boy become an artist. Such a course, he argued, held small chance for future financial success. As for science—well, what did Louis think he could do? But here the boy was as uncertain as his father. He only knew that he would like to carry out the master's ambitions for him, and the first thing was to get to École Normale—just what course he should pursue there might be decided later.

A college training for a tanner boy! Moreover, a training whose entrance examinations provided that he must already have become a Bachelor of Science or of Letters. It seemed altogether impossible. But "where there's a will there's a way," and Louis Pasteur presently found one. A boyhood chum was going up to Paris to study in a famous school kept by a man who had formerly resided in their district—a man who was always glad to encourage "home boys," and to take them on at reduced tuition. Having been furnished with a very favorable report of the abilities of young Louis, this master at once sent word, offering the boy a position where he might work his way.

With what joyous anticipations he and his friend Jules set forth! But alas for the lad who had never known aught but the neighborhood of the tan-yard and the happy companionship of the home circle, he was absolutely miserable amidst the gay sights and scenes of Paris. "Oh, Jules," he would sigh wistfully to his friend, "if only I could get a whiff of the tannery yard, I feel my homesickness would vanish." Fancy longing for such a smell! Jules laughed at first, but presently when poor Louis could neither eat nor sleep, and the most interesting events aroused him not at all, he saw that it was no

matter for a joke, and went to the master in his chum's behalf. Between them they did all in their power to help the lad, and Louis fought his weakness bravely, but he was only fifteen and day by day the longing for home ties grew stronger. At last the master, fearing that the boy was going to become quite ill, privately sent word to the father to come and get him.

How thankfully Louis returned to the home school at Arbois perhaps only he knew, but he did not renounce all hopes of the École Normale. "I shall grow stronger and braver," he reasoned, and when presently an opportunity offered for him to enter a college only twenty-five miles away, he persuaded his father to let him try again. And this time, with occasional week-ends and holiday periods to tide him over, young Louis managed to stick, and withal to do such creditable work that he was made a "supplementary master," and wrote proudly home that henceforth he was to receive his board and lodging and 300 francs (about $60) a year. That he took his work and life generally with all seriousness is shown by a letter written home at this period, in which he advised his sisters to work hard and love one another, closing with the sage remark: "When one is accustomed to work it is impossible to do without it; besides, everything in this world depends on that."

As proof of the loving consideration which prevailed in the family at all times, there is a record of how Louis desired to pay for the schooling of one of the little girls, writing that he could easily earn the extra money by giving private lessons. But his parents would not permit this. They felt that the boy needed all his spare time for his own studies, and instead they wrote wanting to give him a small allowance for a private tutor to coach him.

In 1841, young Pasteur again went to Paris, this

time as part student and part instructor in the school where his first weeks there had been spent. He was obliged to work very hard, and his parents felt so uneasy concerning him that he wrote as follows to reassure them: "Do not be anxious about my health and work. I need hardly get up till 5:45; you see it is not so very early. . . . I shall spend my Thursdays in a neighboring library with Chappius, who has four hours to himself on that day. On Sundays we shall walk and work together; we hope to do some philosophy on Sundays, perhaps too on Thursdays; I shall also read some literary works. Surely you must see that I am not homesick this time."

And, indeed, the young man was now finding many interests. The friend to whom he referred was a young philosophy student, also striving to fit himself for the École Normale. The two had great times mapping out their futures, attending lectures, exchanging notes, and generally coaching one another. To date Louis had gone as far as steady application and desire could take him, but there was lacking the strong spur of enthusiasm: he was on the way so to speak, but he had no definite goal. Then he had the good fortune to attend a series of lectures given by the celebrated French chemist, Jean Baptiste Dumas, who had, like Faraday, the secret of opening "boundless horizons before every mind," and the vivid imagination of young Louis Pasteur was roused to a flame. Now, he knew the course he desired to pursue, and he plunged with such fervor into his studies that shortly he was enabled to pass the entrance examinations to École Normale—he had tried the year before and failed. This time he stood number four on the waiting list!

The following three years were devoted to chemistry; then came the Revolution, in 1848, and for a time the

needs of his beloved France became more urgent than the call of science. Caught up in the great wave of patriotism which swept the land, Pasteur enrolled in the Garde Nationale (a civil militia) and "with unwise but generous ardor laid all his hard-won savings on the Autel de la Patrie, erected in the open street," at the same time writing home: "It is a great and sublime doctrine which is now being unfolded before our eyes . . . and if it were necessary I should heartily fight for the holy cause of the Republic."

At this time came the first great grief of Pasteur's life: his mother passed over to the Beyond. For a time everything crashed around him, then the habit of which he had written his sisters—"when one is accustomed to work it is impossible to do without it"—asserted itself, and he turned again to college and his researches and experiments. His rapid advancement brought him into contact with the leaders of the scientific world in his department—Claude Bernard, Balard, Dumas, Biot, and he was especially interested and drawn to the study of crystals by an announcement made by the latter. He plunged forthwith into a perfect orgy of experiments having to do with the miracles of crystal formation, and at length went to Biot with a most amazing discovery: he had succeeded in proving that the atoms in a molecule were arranged in right-hand and left-hand spirals or other tridimensional figures. The old master, then in his seventy-second year, welcomed the young student generously, but he could not credit that so young an investigator had uncovered such an astonishingly important law in chemical realms. Over and over again he watched Pasteur perform certain experiments until his claims were proved beyond a doubt, then he caught the young man in his arms. "My boy," he cried, "I have loved the sciences so much all my

life that this makes my very heart jump!" And well it might: for the work of Biot's whole life had been crowned by the discoveries of his young pupil and friend.

Pasteur at once began plans for following "the great and unforeseen road" now opened to chemists. But the government, attracted by his success, made him Professor of Physics at the Dijon Lycée,—an appointment which smote Biot like a blow. "What of Pasteur's unique research work?" he raged. "The government seems not to realize that such labors stand above everything else!" And he resolved to see that Pasteur had a post better suited to give scope to his special gifts, for he knew well what the young master did not—that the work at Dijon would prove most tiring to one of Pasteur's conscientious type. More than once he had heard him say: "It is only when I have prepared a lesson very carefully that I succeed in making it very clear and capable of compelling attention. If I neglect it at all I lecture badly and become unintelligible." And Biot knew that there would be such a rush of lesson-preparations in the new position, all untried as its field was to Pasteur, that scientific researches in his beloved chemical avenues would be quite crowded out.

Thus it happened that before Pasteur had begun to languish seriously at Dijon, he was transferred to the more congenial work of Professor of Chemistry at Strasbourg. Here he was soon highly delighted with his surroundings. There was ample time for the study of chemical marvels; he made many dear friends, among these Marie Laurent, the daughter of the Rector of the Academy, who became his wife in May, 1849. "From this time until Louis himself died," one of his biographers records, "his wife was a friend and wife in one, knowing when to leave him absorbed in his work, when to encourage him to talk of it, and when to dis-

tract him from it. Without her he would never have come through triumphant to the end; his achievement was hers too."

Shortly after his marriage Pasteur's researches drew him to tartaric acid. As a commercial product for use in baking powder, dye-stuffs, calico printing, photography, and pharmacy purposes, it was much in demand. But paratartaric, or racemic acid, which is identical with tartaric acid in its chemical constituents, was extremely rare. Might not it be daily being thrown away as a waste product at some of the large tartar-refining factories? Pasteur determined to go and see, and in September, 1852, he set out on his quest. At Leipzig he found nothing, at Vienna he was told that the famous acid had been seen the year before but was not now available, at Prague he was assured that they knew how to produce it, but found that they did not. At length, his money being exhausted, he was forced to return home with the problem unsolved; further than that he was satisfied that no chemist had yet wittingly produced pure racemic acid from pure tartaric acid. Could it be done? He thought so, and the problem would not be dismissed; so with his characteristic doggedness he set about trying one experiment after another until he had effected the conversion. His announcement of the formula brought him no little honor and renown, but after all its personal success lay in the new field to which its discoverer's efforts were brought indirectly.

Pasteur's search among the factories had put him in communication with the action of ferments, an exceedingly important link in his experiments. Happily, too, now that his mind had begun to concern itself with ferment problems, he received an appointment which sent him to the scientific department of the academy at Lille, in the very midst of the distilleries of the land. There

he took up his duties in a very practical manner, taking his pupils about to the various factories and foundries, and, in 1856, even carried them through Belgium for an organized study of industry. Between times his research work went steadily on: "Why does fruit-juice produce alcohol, wine turn to vinegar, milk become sour, and butter rancid?" he cogitated. And presently he produced a paper on lactic-acid fermentation which roused the scientific world to the highest pitch.

"Today," says Hammond, "the contents of this paper seem commonplace enough. It records how Pasteur isolated the trace of greyish substance that can always be found in sour milk, sowed it on sweet milk, and proved that it turned sour. This greyish substance he proved to be a living organism and maintained that in its absence milk will remain sweet indefinitely." [1] But here is the point: up to that time chemists had maintained that the chemical actions taking place during fermentation could be explained only "in terms of molecular physics." How were they astonished, then, to be told that fermentation was the result of bacterial action. "Fermentation, decomposition, and putrefaction," said Pasteur, "are all acts of life, and in the absence of life do not take place. A liquid really sterile, exposed to air really sterile, will remain sterile for ever. Germs follow the general law; they come into the world only from parents like themselves. *La vie c'est le germe et le germe c'est la vie,*" [2] he illustrated happily.

But the leading chemists did not believe him. Indeed, some of the older and more obstinate ones fought him tooth and nail for twenty years, but in the end they were obliged to succumb—the facts as brought out by experiment after experiment confirmed Pasteur at every step.

[1] *Stories of Scientific Discoveries*—Hammond.
[2] "The life it is the germ and the germ it is the life."

And now a new honor came to Pasteur. He was asked to take over the science department at the École Normale—a work which involved a number of difficulties, for the balmiest years of the old college had gone forever, and Biot raged afresh. "Why should a man so valuable to science be obliged to fritter away the best of his time at a job many another might fill just as successfully? The government should pension Pasteur and give him free range in research." But, of course, the government was entirely deaf to any such beneficence.

No matter how hard Pasteur had to delve for the support of himself and his growing family, however, he was not to be turned from "seeing ever more clearly the part played by the infinitesimally small in the economy of nature." Without these microscopic beings life would soon become impossible, he realized, because death would be incomplete. But he was not drawn to this phase of chemistry, nor was he attracted toward antiseptic surgery. It devolved upon Joseph Lister, one of his pupils, working on Pasteur's theory that decomposition springs from living organisms which multiply swiftly under right conditions, to sift out the proper method for checking putrefaction processes in living tissues, and thereby saving the lives of untold millions in the years to come. Pasteur's thoughts had gone deeper than this: he was on the trail of facts to clinch his belief that every disease is caused by a specific germ. And he was stimulated in his desire by the loss of two children from typhoid, and one, a baby daughter, from cholera infantum. "It would indeed be a grand thing," he said, "to give the heart its share in the progress of science." And the memory of his own dear dead caused him to long passionately to save the desolation in other homes.

The first triumph for his theory came in the isolation of the germs which caused the two diseases among the

silkworms, but it was not won without a terrific struggle against the hostility and skepticism of the very people who would be most benefited. In the midst of his study and worry, he was stricken with a cerebral hemorrhage, and though his brain remained clear, one side was paralysed. For some time it was feared that his services in the cause of science were at an end. Then gradually his naturally strong powers rallied, and in three months he was back at his task again, and was shortly enabled to show that the terrible diseases which had practically wrecked the silkworm industry were not only the products of germ contagion but hereditary as well, and to give simple rules for detecting them and stamping them out.

But even so, the silk trade remained only half convinced of the real worth of Pasteur's discovery. "I assure you my grounds are absolute," he wrote to the skeptical Lyons Silk Commission, and in proof whereof he sent four lots of seeds. "Lot 1 is healthy stock," he said; "lot 2 will die of pèbrine; lot 3 will die of flachery; and in lot 4 are some which will develop either one disease or the other." And it all came to pass just as Pasteur said. The "unpractical man of science," as his deriders termed him, had showed conclusively that he held the key to the future of the silk industry.

In 1870 came the Franco-Prussian War, and Pasteur was heart-broken because he had to sit helplessly and watch his country defeated and dishonored: there was no place for a paralytic man. His friends even got him out of Paris on the ground that his would be a useless mouth in the coming siege. But there was one comfort, on the day after Sedan, Lister had published his directions for the cleansing of septic particles from wounds, and thus Pasteur's germ theory had been of infinite value. He received an attractive offer of a professorship at Pisa,

LOUIS PASTEUR
From a photograph

but he would not leave his beloved country in her hour of humiliation; through science he might perhaps raise her head again proudly among the nations. He had been of invaluable help in the improving of wines and vinegar, and when the government asked him to do what he could with French brewing he attacked the problem gladly. Shortly he was able to prove that a microscopic test of the yeast used would control the grade of beer, and further his study of ferments brought him a little nearer his goal. Many micro-organisms, he was assured, must be detrimental to the health of man and animals, and he urged general household *boiling* as a means for disposing of germs in food vessels and clothing.

For some time Pasteur had been working on the problem of anthrax, or splenic fever, a terrible disease which at this time attacked both cattle and sheep with disastrous results. Others had already located the germ and had reproduced the disease in various animals by means of a culture solution, but no one had discovered how to protect animals from it. Pasteur thought results might be achieved by inoculation, and he was untiring in his efforts to find a way. "I have a lasting provision of faith and fire," he wrote to a friend, but in the end it was chance that helped him out. "Chance," however, in Pasteur's parlance held a different meaning from most. "In the fields of observation," he claimed, "chance only favors the mind which is prepared." And there could be no doubt about the preparation of Pasteur's own mind! Even the tiniest jolt set him off on a wide train of coordination and prediction. While working with a pure culture of chicken-cholera germ, he found that it lost its strength merely by keeping, and that a fowl he had inoculated with the weak culture, suffered only a passing indisposition, and was thereafter immune from the disease even when treated with the strongest culture.

"Voila!" he cried triumphantly, and turned again to the anthrax problem with a vim that could not be quenched. Very shortly he had satisfied himself that what would work with a fowl would work with a sheep. Then he broadcasted his theory, and delivered the following forecast: "Take fifty sheep, inoculate twenty-five with a culture of anthrax virus, and then, some days later, inoculate the whole fifty with a very virulent culture. The twenty-five unvaccinated sheep will all perish, the twenty-five vaccinated ones will survive," Knowing full well how this would be received by the public in general, he named a time and place where the experiment would be set in operation. A great crowd of farmers, doctors, and veterinary surgeons assembled, and though there was much chaff and Louis Pasteur was an exceedingly hot-tempered man with little patience for the opinions of his opponents, he kept himself well in hand, and after explaining his theory and doing his best to answer all objections, he personally saw to the inoculation of the twenty-five sheep with the weak culture.

Twelve days passed slowly to those who waited so eagerly; then the crowd assembled again, and the twenty-five sheep previously inoculated were given a second and much stronger treatment. In Pasteur's home and scientific circles the interest had roused to a white heat, and for a fortnight scarcely a day passed without many gathering to view the inoculated flock. But not a single sheep sickened. Then came the day for the final test, when all the sheep were to be treated with virulent culture. Many of Pasteur's opponents were fearful of trickery: the strong virus might be weaker at the top, and thus be given to the inoculated sheep. So they insisted on the vaccinated and unvaccinated sheep being treated alternately; also the virulent tube must be given frequent

violent shakings, and a much larger dose given than Pasteur had intended. But he made no objections; indeed his sureness and serenity as he complied with the demands shamed not a few and silenced them.

However, the results could not be known for a few days longer, and June 2 was named for the last appointment. The first arrivals found the carcases of twenty-two of the second lot lying side by side, two others were dying, and the last one ill. The twenty-five in the first flock were all feeding quietly, and apparently in the best of health. Pasteur, arriving at this moment, was greeted with loud cheers. He had won out. Henceforth, anthrax need not be feared; the sheep and cattle of the country were saved. Pasteur was ready for his next step: the discovery of a vaccine for hog cholera. But first he had one definite order to give: "Burn the carcasses. If the dead are buried, microbes of the disease may later be brought to the surface by earthworms and beetles."

For some time Pasteur had been investigating rabies, but so far he had not found the germ, being greatly handicapped by the length of the incubation period of the disease, and by its extreme deadliness. The popular idea was that the saliva was the chief seat of the disease. Pasteur satisfied himself that it was in the brain and spinal cord, and particularly in the medulla oblongata—that part of the cord nearest the brain. Inoculation from the dried medulla oblongata of a mad dog injected by trephining into the skull of another dog invariably brought on the symptoms of rabies. But, owing to the length of incubation, it was not practical to secure virus from dogs, besides there were the animals themselves to be considered, and Pasteur was one of the most humane of men; he shrank from giving pain in any way. Rabbits offered a better medium. The disease developed

more quickly, and rabies in rabbits was attended only by a painless paralysis. But even after virus of required strength was secured, it was sometime before Pasteur could fix on a definite protective treatment. Then he found that *if inoculation followed, instead of preceding,* the bite of a mad dog, the patient was protected from the consequences.

"I take two dogs," he said in his paper setting forth his discovery. "I have them bitten by a mad dog. I vaccinate the one, and I leave the other without treatment. The latter dies of rabies; the former withstands it. But, however I should multiply my cases of protection of dogs, I think that my hand will shake when I have to go on to man."

Indeed, Pasteur could not bring himself to experiment upon man, and it was more than a year after he was satisfied that death from rabies no longer need result before a patient was literally thrust upon him, in the person of a little Alsatian boy, badly bitten in fourteen places and covered with blood and saliva. The wounds had not been carbolized until twelve hours after their infection; the child's system must already be thoroughly filled with rabies microbes. Death seemed inevitable unless Pasteur's treatment could avail, and the good man waited only long enough to get a physician's confirmation on the patient's condition.

Poor little Joseph was much frightened at first. But he soon found there was nothing in the cure to fear, and he became quite happy playing with the laboratory animals —the chickens, rabbits, guinea-pigs, dogs, and white mice; while as for M. Pasteur, the boy loved him dearly, and would not go to bed without his good-night kiss. Imagine then, the days of the man who held the little life in his hands: sleep almost refused him as the treatment progressed and the virus inoculations increased in

strength, but at length the incubation period passed and the boy was safe and well. The first human case had proved a complete success.

Pasteur's next case was a young shepherd who did not reach Paris until six days after he had been bitten; yet the inoculation saved him also, and news of the two cures spread round the world. In the next six months, 350 cases were treated, and only one life was lost, that of a little girl who was not brought in till thirty-seven days after being bitten. During the first year, Pasteur's method saved about 1000 lives, and the government, thoroughly roused to the importance of his discovery, appointed a Commission to raise money for the building of the Pasteur Institute for the preventive treatment of hydrophobia. It was opened in Paris, 1888, and through it and other institutions since founded, Pasteur's grand service for mankind lives on.

Some years previous to the building of the Institute the government had conferred upon Pasteur a life annuity of twelve thousand francs, a sum equivalent to the salary he had earned as Professor of Chemistry. And the grant was in every respect wise and just, for while Pasteur held that "science is of no country and that its conquests belong to mankind," he was still intensely patriotic, and his idea of raising France through science kept him so active in her behalf that, as Huxley observed, "his discoveries alone would suffice to cover the war indemnity of five millions paid to Germany in 1871."

Slowly now Pasteur's work slipped from his hands; he was growing "weary and old with service," and quite willing to pass on the growing conquest of germ isolation to younger but not more enthusiastic chemists and scientists. Death finally claimed him September 28, 1895, at the age of seventy-three. Had it come earlier and broken his work in two, as seemed probable at one time,

his life would still have had much to emulate, for he had his own high ideal of obeying the laws of humanity and extending the frontiers of life, and he followed it day by day. All men may not hope to be Pasteurs, but all may profit by his life example, and fortify themselves with such another "provision of faith and fire" as will carry them successfully to their goal.

JEAN HENRI FABRE

Jean Henri Fabre is often called the poet of science and the insects' Homer. "He is the wisest man, and the best read in the book of nature of whom the centuries have left us record." So wrote a distinguished English critic, and this coupled with the fact that Fabre was mainly self-taught, and that his life was a never-ending struggle with poverty and disappointments, but increases our admiration of his wonderful achievement in breathing life into what had previously been a lifeless subject.

Fabre's fellow professors always regarded him jealously. He made his class work so interesting that his benches were filled to overflowing, and not infrequently some professor whose ranks had deserted him would remark dourly that there was more romanticism than fact in Fabre's nature studies. He was too interesting! Imagine! Fabre defended himself once for all time:

"Come here, one and all of you," he wrote, addressing his friends, the insects. "You, the sting-bearers, and you the wing-cased armor-clads—take up my defense and bear witness in my favor. Tell of the intimate terms on which I live with you, of the patience with which I observe you, of the care with which I record your actions. Your evidence is unanimous; yes, my pages, though they bristle not with hollow formulas or learned smatterings, are the exact narrative of facts observed, neither more nor less; and whoso cares to question you in his turn will obtain the same replies.

"And then, my dear insects, if you cannot convince these good people, because you do not carry the weight

of tedium, I, in my turn, will say to them: 'You rip up the animal and I study it alive; you turn it into an object of horror and pity, whereas I cause it to be loved; you labor in a torture-chamber and dissecting-room, I make my observations under the blue sky to the song of the cicadas; you subject cell and protoplasm to chemical tests, I study instinct in its loftiest manifestations; you pry into death, I pry into life . . . I write above all for the young. I want to make them love the natural history which you make them hate; and that is why, while keeping strictly in the domain of truth, I avoid your scientific prose, which too often, alas, seems borrowed from some Iroquois idiom.'"

Jean Henri Casimir Fabre was born in 1823, at Saint-Léons, a small market town in southern France. That he owed nothing whatever to heredity the old naturalist once pointed out at some length in a charming paper which later came to be included in one of his books. He knew little of his maternal grandparents save that they were hourly concerned with the problem of getting a living. With his father's people, away out on a poverty-stricken hillside, he lived months on end because his own father and mother were too poor to care for him. "They did not know how to read," he tells us; "they had never opened a book in their lives. Grandfather knew a great deal about cows and sheep, but nothing about anything else. How dumfounded he would have been to learn that, in the distant future, one of his family would spend his time studying insignificant insects! If he had guessed that that lunatic was myself, seated at the table by his side, what a smack I should have caught in the neck! 'The idea of wasting one's time with that nonsense!' he would have thundered."

To this grandmother, Fabre felt, he was indebted for physical vigor and love for work. She was, also, a good

story teller, evenings round the fire when the day's heavy tasks were done. She stimulated the boy's imagination, but she certainly gave him no love for insects. Neither did his own parents. His mother could neither read nor write; his father had these accomplishments to a small extent. "But," Fabre records, "he was too busy making a living to have room for any other cares. A good cuff or two when he saw me pinning an insect to a cork was all the encouragement I received from him."

Yet somehow even as a very small child, young Jean Henri began to inquire into things. It was, in fact, a special gift. Just such an one as he himself cleverly explains: "One child takes to music, another is always modeling things out of clay; another is quick at figures. It is the same way with insects. One kind of bee can cut leaves; another builds clay houses; spiders know how to make webs. These gifts exist because they exist, and that is all any one can say. In human beings, we call the special gift genius. In an insect, we call it instinct. Instinct is the animal's genius." And a love for and a desire to know the whys and wherefores of all insects was Jean Henri Fabre's special genius, and one which he began to cultivate in his earliest years. His pockets were always filled with an interesting collection; he had specimens tucked away in all sorts of odd corners and crannies, and it is very probable that his good mother quite often lost patience with his storing propensities. His first duty, as herdsman of ducks, quite filled the little fellow with joy—not for the pleasure he expected to get from the ducks, but because their charge led him to the pond where the water-beetles, the tadpoles, the orange-bellied newts and the caddis-worms dwelt in a round of what seemed at first perpetual pleasure. It was a great day when little Henri discovered that each of these citizens had a part in the daily scheme of life, and that each

one existed for the performance of some work in Nature's universal plan.

The small boy had but little schooling. The schoolroom, in the home of his godfather, was "at once a school, a kitchen, a bedroom, a dining-room, and, at times a chicken-house and a piggery." For, frequently when the youngsters went out they were careful not to close the door in returning, then the dozen little porkers, wallowing in their stone trough outside, were quick to smell the schoolroom odors, and come running in. "They rubbed against our legs," he tells us. "They poked their cold pink snouts into our hands in search of a scrap of crust; they questioned us with their sharp little eyes to learn if we happened to have a dry chestnut for them in our pockets. When they had gone the round, some this way and some that, they went back to the farmyard, driven away by a friendly flick of the master's handkerchief." Next came the hen and her brood of velvet-coated chickens, and how eagerly the youngsters scattered crumbs filched from their lunch pails, and vied with one another in getting their fingers on the soft, downy backs.

What could they learn in such a school! Besides, schoolteaching was only a small part of the master's daily round. He was bailiff for an absentee landlord, a barber, a bell-ringer, and a choir-leader. In summer, the boys all helped in the fields and garden and there was no more formal book-learning than that which prevailed in the famous school kept by Old Squeers, lessons being frequently quite forgotten under the pressing business of getting in the crops, cleaning the pigeon houses, or killing snails in the box borders of the ancient castle for which the master was responsible. Since he seldom had time to hear the small boys, being too much occupied with the larger ones, it is not to be wondered at that young Henri found lessons uninviting, and came to look forward

eagerly to the field-days when he might make the acquaintance of frogs, locusts, and beetles, and we are told that "while on the snail-hunts he followed the example of Saul when he spared the Amalekites, by surreptitiously pocketing the snails with their pretty shells instead of obeying the order that they should be utterly destroyed!"

Fabre records that always his passion for animals and plants made progress of itself, but he did not get on with his letters. In common with all the small boys of his age he had " a little penny book," containing the alphabet and a beginning in words of one syllable. But, save the pretty pigeon on the cover, it was all a puzzle to him till one day his father happily brought from town a colored print in which animals of all sorts taught the a b c's by means of the first letters of their names. It interested the boy, and shortly with his father's help he knew his letters. Then he began to explore "the pigeon book," and presently, marvel of marvels, he had learned to spell. His parents were quite amazed at this unexpected progress. "But," Fabre writes, "I have the animals to thank for teaching me to read. Animals forever!" As a reward for his diligence the boy was given a cheap edition of "La Fontaine's Fables." It was crammed with pictures, "small and very inaccurate, but still delightful. Here were the crow, the fox, the wolf, the magpie, the frog, the rabbit, the donkey, the dog, the cat; all persons of my acquaintance. The glorious book was immensely to my taste, with its skimpy illustrations in which the animals walked and talked. As to understanding what it said, that was another story!" But it did not long remain so. The boy was awake now; he meant to learn to read, and to go on and explore the mysteries of various books.

Then came a happy change in the boy's environment; Antoine Fabre took an unprecedented step in the annals

of his family. He left his native village for the town of Rodez. There he kept a café, and Henri, now a bright little fellow of ten years, easily succeeded in getting permission to attend the lycée in exchange for small services about the chapel. "I was well thought of in the school," he tells us, "for I cut a good figure in composition and translation. In that classical atmosphere, there was talk of Procas, King of Alba, and of his two sons, Numitor and Amulius. We heard of Cynœgirus, the strong-jawed man, who, having lost his two hands in battle, seized and held a Persian galley with his teeth, and of Cadmus the Phœnician, who sowed dragon's teeth as though they were beans and gathered his harvest in the shape of a host of armed men, who killed one another as they rose up from the ground. The only one who survived the slaughter was one as tough as leather, presumably the son of the big back grinder-tooth."

Fabre admits that he could not have been more startled had they talked to him of the man in the moon as a reality. But he persevered, and presently came on by easy stages to Vergil which he learned to love because of "the exquisite details concerning the bee, the cicada, the turtle-dove, the crow, the nanny-goat, and the golden broom." Interested as he now was in nature book lore, he did not forget his delight in the subjects at first hand, and the Thursday half-holiday was looked upon as the red-letter day of the week.

Thus four years passed, then Antoine Fabre moved to Toulouse, where he again kept a café and Henri attended school at the chapel. Ill-luck, however, pressed them close, and a third move was made, this time to Montpellier, but their fortunes did not improve. Indeed, affairs presently became so straitened that the boy Henri, then just turned fifteen, was forced "to put his trust in God and take to the road to earn his penn'orth of potatoes

as best he could." Life was soon "a hideous inferno," and Fabre himself never afterward liked to dwell on the grey and lonely hours that were then so often his. "Let us pass quickly over this phase," he says. "During this sad time, my love for the insects ought to have gone under. Not at all. I still remember a certain pine cockchafer met for the first time. The plumes on her antennæ, her pretty pattern of white spots on a dark-brown ground, were as a ray of sunshine in the gloomy wretchedness of the day."

Good fortune, which as Fabre wisely observes, "never abandons the brave," finally brought the lad to the École Normale, in the days when the college entrance examinations were not so very stiff. Finding that he could work his way if he could pass muster, the youth "plucked up courage and sailed in an easy first." Three splendid years followed—years in which he was sure of food and had ample time for getting his vague knowledge of plants and animals in order. For, thanks to his application in the schools of the priests, he now found himself considerably in advance of his fellow students in some ways, and thus was enabled to hoard many spare moments for examining treasures hidden in the recesses of his desk—"the oleander's fruit, the snap-dragon's seed-vessel, the wasp's sting, and the ground-beetle's wing-case."

But, much as he loved natural history, the young man had to force himself to turn from it. "The schoolmasters of the time despised it," he tells us. "Latin, Greek, and mathematics were the subjects to study." So he buried his natural history books and specimens in the bottom of his trunk, and entered into a zestful struggle with higher mathematics. Philosophizing on this period of his life many years later, Fabre set down the following passage: "We never know what will happen to us. Mathematics, on which I spent so much time in my youth,

has been of hardly any good to me; and animals, which I avoided as much as ever I could, are the consolation of my old age."

In his twentieth year, Henri Fabre accepted a position as teacher in a primary school, at the princely salary of 700 francs (around $135) a year. The schoolroom was "a sort of huge cellar oozing with damp," lighted by "a narrow prison-window, with iron bars," and the school furnishings consisted of a plank bench running round the room, a seatless chair, a blackboard, and some chalk. "Under these conditions," Fabre records, "I was supposed to keep profitably employed some fifty young imps of different ages, but alike in their determination to play tricks on the new master." His one resource was his tongue; his only weapon a stick of chalk, but with these he managed to keep up such a strong guard that his young opponents "in the unequal contest" not only never managed to break through, but gained daily in respect for the master, and the fame of the school shortly began to go abroad.

At the beginning of the second year Fabre was granted an assistant, and was thus enabled "to create a division of younger boys and real duffers and so to keep a more homogeneous class of older and brighter boys for himself." Being fortunately able to choose his own curriculum, he determined to teach his pupils chemistry—the composition of the soil and plant foods for the young agriculturists; and the important facts about soap-making, stills, tanning, metal working, pickling, etc., for those who hoped to engage in manufacturing pursuits. So successful was this undertaking that, as Fabre humorously says, "some more places were laid in the dining-room, and the Principal, who was more interested in the profits on his beans and bacon than in chemistry, congratulated me on this accession of boarders."

Another original feature was the institution of outdoor geometry and surveying, which is interesting today principally because of the delightful discovery which work in the latter branch uncovered for the Nature lover. Being engaged with his boys in surveying a plot of ground in an untilled field, the master soon found the boys giving haphazard attention to the matter in hand: "One, sent to plant a stake, would stop frequently and stoop down; another, despatched to find an arrow, would pick up a pebble instead; a third, supposed to be measuring an angle, would be seen crumbling a clod of earth; while almost all would be found licking bits of straw." What were they about? Fabre good-naturedly stopped operations and inquired into the reason for their defection. He was shown the clay nests of a certain species of black bee, and initiated into the pleasure of sucking up the strong-flavored honey through a straw. The experience was like setting fire to tow: it aroused all Fabre's carefully stoppered enthusiasm. He went home and dug up his nature books; then, not finding the name of the particular bee in question, he spent the money literally needed for his daily bread for a magnificently illustrated book on insects and the best authority then obtainable. "In it," he tells us, "I learnt the name of my black bee; I read for the first time various details of the habits of insects; I found, surrounded in my eyes with a sort of halo, the revered names of Réaumur, Huber, and Léon Dufour; and, while I turned over the pages for the hundredth time, a voice within me seemed to whisper, 'You also shall be of their company!' "

Nor was this day so very far distant. Fabre's fame as a school-master had gone abroad, and now came a substantial offer from the lycée at Ajaccio, tendering him the professorship of physics and chemistry at about three times the salary he was then receiving. Moreover, the

work was much lighter, and there would be ample time for his observations of nature. With what joy the teacher-naturalist accepted and betook himself to the new post! Of this period he writes: "The temptation is too much for me. The sea, with its wonders, the beach, covered with beautiful shells, the myrtles, arbutus, and other trees; all this paradise of gorgeous nature is more attractive than geometry and trigonometry. I give up. I divide my spare time into two parts. The larger part is devoted to mathematics, by which I expect to make my way in the world; the other is spent, with much misgiving, in botanizing and looking for the treasures of the sea."

Fortunately for the teacher's peace of mind, two famous scientists presently came to Ajaccio: Requien, a well-known botanist, and Moquin-Tandon, a philosopher and poet, who gave Fabre his first—and last—lesson in vivisection, using a snail for a specimen, and sketching and explaining the organs which he spread before the reluctant eyes of the nature lover. Fabre was interested in life not in death: he cared nothing for the anatomy of his subjects. What he wanted was to observe their daily habits; to find wherein each one helped in the Divine plan, and he longed unspeakably to delve deep into this absorbing study—a desire Moquin-Tandon did his best to encourage: "Leave your mathematics," he counseled. "Get to the beast, the plant; and if, as I believe, the fever burns in your veins, you will find men to listen to you."

There followed months in which every spare moment was given over to the study of plants and animals. Then Fabre's interest was drawn to insects through a brilliant paper written by Léon Dufour, the world's leading entomologist; he felt that here was the greatest oppor-

tunity for original work, and shortly he published an article supplementing Dufour's, which brought him special notice and a prize from the Institute of France.

About this time Pasteur came to the École Normale where Fabre was now teaching. The great experimentalist was on the trail of the silkworm disease, but to date he had never seen a cocoon. How Fabre must have delighted in furnishing first-hand information! But he himself was far from achieving the success which seemed nearing Pasteur: he was still laboring with physics and chemistry, and longing with all his soul to be installed as Professor of Natural History. One unsought mark of distinction, however, was soon his. Victor Duruy, the Minister of Public Instruction, visiting Fabre in his laboratory, was struck with the independent character of his researches—the master at the moment being engaged in experimenting with dye-stuffs. On his return to Paris, he was instrumental in placing Fabre's name in the list of the Legion of Honor, and sending for the master himself gave him the accolade, at the same time remarking, "You will like the ceremony all the better if it is held in private, between you and me; I know you."

Besides this honor, the Minister gave Fabre a number of scientific books and sufficient money to pay his fare for the round trip, insisting also that he remain as his guest and attend a reception of learned societies which the Emperor was holding the following day. Under threat of being haled in by the gendarmes, Fabre consented, but he had no desire to shine at Court, and he could never again be persuaded to attend a high social function.

In 1858, Fabre won his degree and a professorship in Natural Science, but he never attained to the honored position of head of his department—jealousy, lack of

capital, and his inability to push himself being the prime factors which kept him back. For the narrowness of mind which weighs a man's capital instead of the man himself the teacher-naturalist had the utmost scorn: "Be as ordinary, as commonplace as you please," he writes in "The Life of a Fly," "but, above all, possess the coin that lets you cut a dash. That is the main thing; the rest is a secondary condition." Jealousy, too, he regarded as beneath the dignity of a man of letters. But though he himself would not stoop to such pettiness, others were not above it, and it was the machinations of his colleagues which finally undermined his position and drove him from the profession. He was even turned out of his house in the neighborhood because the owners, two maiden ladies, were led to believe that his teachings in natural history were irreligious. Many years later, the textbooks which he had written and which were so useful at this period were discontinued because they contained too much religion!

Adrift on the world at forty-six with a wife and five children, what was he to do? Seek an opportunity elsewhere in the profession? No, he was done with its jealousies and backbiting. Perchance a livelihood might be gained from commercializing a dye secret he had just discovered, and at once a dream factory "rose skywards, full of promises." Ere it could be materialized, however, the chemists discovered how to produce alizarin synthetically. He could not compete with their methods in cheapness and quality, so all hopes were at an end of making money from vegetable coloring matter. What now? For the moment, Fabre was quite crushed. "It is all over," he cried, "the downfall of my hopes is complete!" Then he rallied, and began, as he said, "to gather up the fragments that remained."

The school books that he had written were bringing in

a little money, sufficient with care to stave off the wolf for a time. His lectures on natural history had ever struck a popular vein, and presently it was borne in upon Fabre that he had another possible means of livelihood, and one which appealed to him from every angle. "Let us try another lever," he cried enthusiastically, "and resume rolling the Sisyphean stone. Let us seek to draw from the ink-pot what the madder-vat and the *alma mater* refuse us. *Laboremus!*"

First he must have a house and garden of his own—a little spot where none might interfere with his plans and studies. After diligent search, he was enabled to find just what he wanted near Serignan, and with it a small piece of waste ground where insects and thistles rioted—"a cursed ground," he wrote, "which no one would have as a gift to sow with a pinch of turnip seed, but an earthly paradise for bees and wasps," and, of course, for the man who delightedly moved his family thither at once. "It is a little late, O my pretty insects," he said, half-sorrowfully. "I greatly fear the peach is offered to me only when I am beginning to have no teeth wherewith to eat it." But it was not so. The Fates were kind, and Jean Henri Fabre was spared for many happy years with his precious studies. His great ten-volume work *Souvenirs entomologiques* was not seriously embarked upon till his fifty-sixth year, and was put down bit by bit, with an utter absence of what he termed the "official jargon of science," during a period which lasted nearly thirty years, and always only after the most painstaking and carefully accurate observations. They are, moreover, "delightfully human documents as well as accurate studies of insect life. "Listen, for example, to his account of the courtship of the scorpions,[1] gleaned from watching two dozen

[1] "The Life and Love of the Insects," chapts. 17 and 18, A. T. DeMattos' translation.

specimens which he had imprisoned in a great glass cage in the garden:

"Front to front and claws drawn back, two wrestlers assume the acrobat's 'straight bend. . . .' Then the tails, held vertically erect in a straight line, exchange mutual rubs, glide one over the other, while their extremities are hooked together and repeatedly fastened and unfastened. Suddenly the friendly pyramid falls to pieces and each runs off hurriedly and without ceremony." This strange performance, Fabre discovered, was usually a sort of preliminary "setting to partners," which, once satisfactory, ended in a lengthy dance or lover's stroll. "Nothing shows the object which the strollers have in view. They loiter, they dawdle, they most certainly exchange ogling glances. Even so, in my village, on Sundays after vespers do the youth of both sexes saunter along the hedges, every Jack with his Jill. Sometimes, he draws her to him, and, though she has no face, but only what is to us a horrible mask, he gnaws and tickles with his lower jaws the equally hideous mouth opposite. It is all superb in its tenderness and simplicity. The dove is said to have invented the kiss. But I know that he had a fore-runner in the scorpion."

Interesting as are all of Fabre's writings, scientists regard as his most important work the light he has thrown on the subject of instincts. In the customary conditions of their lives many insects, he shows, have a "perfect wisdom, comparable with and even superior to human wisdom," but outside their regular round they exhibit only "the most incredible stupidity." As a routine worker, the insect provides a most commendable example, the thriftiness of the ant and the industry of the bee having been proverbial since Time immemorial. With the problem of inprovisation, the whole race is, however, utterly at a loss. A sand-wasp whose well Fabre had

plundered calmly sealed it up with the utmost precaution, although even the most casual glance must have shown her that there was now no need for so doing. Another wasp, finding herself shut out from home, frenziedly dug her way in, as she would if an avalanche of dirt had closed her entrance. Once inside and imprisoned with her house-mates, she made no effort to dig out again, but beat her wings helplessly against the bell glass in company with her comrades and finally perished with them.

No more interesting reading is to be found than the translations of *Souvenirs entomologiques,* and above all these records show, as can not be done here, how painstakingly and carefully the old naturalist worked, and how faithfully the whole family assisted him, cheerfully taking their turn on the observation shifts, and thus enabling him to prove every point before going on to the next step, and making him what Darwin justly termed "an incomparable observer." During the last years of his life, Fabre's fame spread so rapidly that in his eighty-eighth year a grand celebration was held for him in the village of Serignan. Many famous persons were present, and letters and telegrams poured in from all parts of the globe. He died five years later, in 1915, at the advanced age of ninety-two.

LORD KELVIN

Lord Kelvin (William Thomson in private life) stands on the world's honor roll as one of the greatest physicists, and to his influence is due the recognition today that the best type of engineer must be a true man of science as well. He taught and put into practise that "the best performance of the everyday occupations of mankind are those to which the principles of science are rigidly applied." To the kind of work which he thus instituted has been given the term, "applied science."

The number and importance of Lord Kelvin's discoveries and original researches are truly remarkable; yet concerning the details of most of these we must be silent, for they are so bound up with arguments derived from higher mathematics that very few people are able to follow them. He made great strides in the theories of elasticity, vortex motion, heat, electricity, and magnetism. To his ability as an engineer was due the success of laying the Atlantic cable. He invented the mirror galvanometer used for cable signaling, and devised the siphon recorder which is still in use for receiving the signals. From his observations, also, he issued a statement that more than a half century of practise has been unable to disprove, namely that a limit to the speed of cable operation would early be reached owing to the effect of the statical capacity.

He was the inventor of various pieces of electrical apparatus and methods for measurement. The present form of mariner's compass, which is free from the magnetic action of the ship's iron, and a deep-sea sound-

ing apparatus, also in wide-spread use, owe their origin to his untiring activities. As early as 1842, he contributed largely to the theories now upheld concerning the age of the earth; he was also greatly interested in the problems resulting from the discovery of radium, and the theory of electrons. He was a voluminous writer for scientific journals, and because of his wide knowledge in many fields, a most interesting speaker upon the platform. His "Popular Lectures and Addresses" are to be had in three volumes; his "Mathematical and Physical Papers" comprise six volumes; besides these is another volume of reprints from his papers on "Electricity and Magnetism," and a book, "Elements of Natural Philosophy," written in collaboration with a fellow professor.

William Thomson was born at Belfast, June 26, 1824, being the second son of Professor James Thomson, head of the mathematical department of the Royal Academical Institute—a man who had risen to this high post from a most humble beginning simply by hard work, pluck, and determination. William's mother was the daughter of a Glasgow merchant, and taking into consideration the fact that the Thomsons originally emigrated from Scotland to escape the religious persecution of the Covenant times, there was, notwithstanding the Irish birthplace, the pure blood and indomitable spirit of the Scottish Chiefs in his veins, and withal the proverbial seriousness of outlook and hardiness which characterizes the typical Scot. Four brothers and three sisters made a happy childhood for young William. But while all were still young, the mother passed away, leaving the father with the strenuous task of their upbringing—a feat which the professor accomplished with such a judicious mixture of affection and keen discipline that eventually all his sons rose to ranks of distinction in the world's activities.

In 1832, when William was but eight years of age, an

advantageous offer came from the Mathematical Department of the Glasgow University, and the professor at once migrated with his little flock to the land of his ancestors. Thus began an association with Glasgow which was to stay by William until his death seventy-five years later. And how proud, too, the lad must have been of being a Thomson, for even before his father's advent there were so many Thomsons among the faculty, that students and townsmen often spoke of the school as the Thomsonian University! Both William and his elder brother James early showed remarkable mental abilities, and so capably did the professor oversee their studies that at the astonishing age of ten and twelve respectively they were enabled to pass the entrance examinations to the University. Moreover, they held their own among their fellow students so successfully that it was a commonly accepted fact for William to come out at the head of the class, with James a close second. Nor was the course an easy one in any sense of the word; it included Lagrange's "Theory of Functions" in mathematics, Newton's "Principia," Laplace's new and difficult work in natural philosophy, and equally obtuse studies in logic, moral philosophy, and chemistry, not to mention the stiff readings in Latin and Greek. And, too, the competition was of the keenest character, there being several very brilliant young men in the class, among these John Caird, who was afterwards at the head of the University.

In the summer of 1840, the professor broke away from the family group for a brief holiday, taking his two talented sons with him for a tour through Germany. He wanted the two boys to have an opportunity to study the German language at first hand, but unfortunately for the success of the father's project, there fell into William's hands Fourier's great work on mathematical physics which had already given to countless students a marked

stimulus toward experimental inquiry. It proved magical to the youth of sixteen, and was with him both sleeping and waking to such purpose that the whole of his later career showed how definitely he had been influenced by the author's master mind.

"If you are going in for natural philosophy, my son," the father advised, "you must go to Cambridge." And so, in the fall of 1841, young Thomson was admitted as a student at St. Peter's. Now the one who came out at the head of the Cambridge Mathematical Tripos lists was designated as "The Senior Wrangler." It was an honor to which William Thomson at once aspired; he secured the assistance of a renowned tutor, William Hopkins, and began to dig with the deepest vim and enthusiasm. Shortly he was contributing some very able papers to the Cambridge Mathematical Journal, and being spoken of everywhere as a particularly brilliant student. But he was wise enough not to stick too closely to his books and researches. He kept himself fit physically by going in strong for athletics, particularly rowing and swimming, and he kept the cobwebs from thickening on his mental horizon by taking a keen interest in music, for which he showed such marked talent that presently he was made president of the University Musical Society.

As the date for the Tripos contest drew near, both William and his father felt their hearts beating with anxiety. The requirements of the examiners involved the young man in a lot of study which did not particularly interest him, and for which he would have small use in pursuing the career he had marked out for himself, that of physicist or student of applied science. But he wanted the honor, and it would count heavily toward securing a position as professor of natural philosophy at Glasgow—a post which would soon be vacant, and one which the elderly professor had set his hopes on having his son fill.

So he crammed as best he could, and hoped against hope.

When the results of the examination were made known, however, it was found that he stood second on the list. Parkinson of St. John's had carried off the prize of Senior Wrangler. But there was another valued mathematical prize which might yet be William's—that of Smith's Prizeman. Together with Parkinson he went for it, and this time Thomson was first and "Park" second. As to the ability which the reception of the two honors testified, some inkling may perhaps be gleaned from the comment of one of the examiners to another: "You and I are just about fit to mend young Thomson's pen," he said.

Thomson now set out for Paris to study under the famous Regnault, a physicist on whose foundation work whole chapters in theoretical and physical chemistry have since been built by other investigators, not the least of these being Thomson's own contributions by reason of a wonderful series of experiments for determining the various constants in the theory of heat. In London, the young student met Faraday, and was quite charged from contact with the great master electrician. But he was not tempted to deviate from the course he had marked for himself, and when presently the expected offer came tendering him the chair of Natural Philosophy at the Glasgow University, he was glad to accept. He was now but twenty-two years of age, yet thoroughly competent to undertake the instruction of others in the vast science to which he had dedicated his life.

His inaugural address, delivered in November, 1846, was an introduction to the scope and methods of physics, and was considered very able indeed, notwithstanding that in the beginning the young man was almost overcome from nervousness. It soon developed, however, that Professor Thomson had few of the requirements of a

natural teacher; he was prone to forget the groping minds before him, and go wandering off after some abstruse idea suggested by the subject in hand. Not infrequently he quite forgot his class altogether and filled the blackboards with "what was in fact a real exhibition of research in the making." Since many of his pupils were there only because their course compelled so many credits in physics, they made little or no effort to follow him, and often found themselves considerably bored and forced to create diversions of their own. "I listened to his lectures on the pendulum for a month," one youth is reported to have said, "and all I know about the thing yet is that it wags."

Professor Thomson was himself, however, keenly alert for clear physical meanings, and sought continually for avenues leading from the stereotyped phrases of the text-book. That he failed to make his procedures plain to others was a most regrettable misfortune. Always, however, there was both fascination and inspiration in his digressions for those who had the ability to appreciate them, and sometimes he illuminated a point with lightning clearness. For example, it is recorded that on a certain occasion, the professor asked a student to explain the meaning of the symbol $\frac{dx}{dt}$. "Sir," returned the young man, with no little complacency, "It denotes the limiting value of the ratio of the increment of x to the increment of t when the latter increment is indefinitely diminished." "Hmm," observed the instructor shortly, "that's what Todhunter would say. Does nobody know that it represents a velocity?"

Fortunately for Professor Thomson's own researches, the University sessions covered only six months of the year, and he was left with considerable latitude for uninterrupted discoveries. That the first of these had to do with things electrical was no doubt due to the impres-

sions he had but recently received from Faraday. With his methods we have no time to deal, and must content ourselves merely with stating that he figured out how to determine the unit of current in both the volt and the ampère and established what is known as the standard ohm—a measuring unit which he secured by applying to his absolute measurements of the volt and the ampère the consequences of Ohm's Law. He was a pioneer, too, in an electrical movement which was to become "one of the most dramatic of all discoveries of twentieth century science—viz., wireless telegraphy." In a brilliant paper, "On the Oscillatory Discharge of a Leyden Jar," given before the Glasgow Philosophical Society, Professor Thomson proved not only that this *phenomenon,* as it was then considered, was true, but he produced a formula for determining the rapidity with which the oscillations took place. From this humble beginning, Clerk Maxwell, one of Thomson's contemporaries, showed that if the oscillations could be made sufficiently rapid, much of the energy stored in the Leyden jar could be radiated into space in the form of electro-magnetic waves; Hertz, following the idea still further, not only produced such waves, but devised a method of receiving them—and in the minds of scientists the scheme of wireless telegraphy was born. It remained for such men as Sir Oliver Lodge, Signor Marconi, and their contemporaries and followers to work out what now seems an almost indispensable item in world progress.

Thomson had gone to Paris to study thermodynamics, that is, the physical forces or laws relating to the theory of heat. It was to be expected, therefore, that he would pursue various investigations along this line. Up to this time authentic researches involving this subject were embraced in his master's (Regnault's) experiments on steam, and the discovery of one Nicolas Carnot that it

was *not only possible to convert mechanical work into heat but also that the process might be reversed and heat converted into mechanical work;* and also that *to a given amount of mechanical work there is a corresponding definite amount of heat.* However, nobody seemed to attach any particular importance to these points until Thomson drew the attention of the scientific world to them in a paper, published in 1849, under the lengthy heading: "An Account of Carnot's Theory of the Motive Power of Heat, and Numerical Results from Regnault's Experiments on Steam."

"We-ll," observed the physicists slowly, "that being so, it is not difficult to deduce a doctrine concerning the conservation of energy, viz., the total energy in the world must be constant. Therefore, when energy disappears in one form, say as heat, it must reappear in its counterpart, mechanical energy, or vice-versa."

All well and good. But this inference was of no particular moment until the actual mechanical equivalent of heat had been determined. There ensued a great amount of experiment and investigation, and presently a scientific amateur, James Prescott Joule, a young brewer by trade, rose up in his home city of Manchester and sought to show how he had obtained "a result of 778 foot-pounds of work as the mechanical equivalent of the pound-degree Fahrenheit." But, notwithstanding that the "Manchester Guardian" exploited him faithfully, other newspapers failed to be impressed, and the discovery seemed doomed to oblivion. But Joule, though exceedingly modest, was not to be easily dissuaded. He felt that he had made a real discovery, and he finally succeeded in getting permission to read a paper before the British Association at Oxford. He was nervous and his delivery poor, and the harried chairman, thinking his paper of little moment, had previously advised him to be

brief. At the close of what was little more than a skimming of the real paper, the learned gentleman in the chair was passing the subject without even an invitation to discussion, when Professor Thomson jumped to his feet and aroused the audience by showing what the theory might do towards determining the amount of energy in an electrical circuit. Today Joule's Laws are standards in thermodynamics. "But," said Lord Kelvin, when in Manchester, in 1893, he unveiled a statue of Joule, "there was no consciousness in the very unassuming young man's manner that he had a great idea to unfold."

To the researches of Carnot and Joule, Thomson was indebted for the clues which led to a very important contribution toward the making of reliable thermometers, namely a scale of temperatures now universally known as Thomson's absolute thermodynamic scale. Since this scale is solely concerned with the work done by the thermometric substance employed, and is totally independent of all its physical properties, it is absolutely the most satisfactory scale of temperatures known, and is the one always called into account where the applicability of ordinary thermometers is limited. For instance, under certain conditions, the liquid of a thermometer may freeze or may evaporate, or the material of the bulb may change its volume, or in the case of gas thermometers some of the gas may be absorbed. Thus a mercury thermometer cannot be used accurately above 450° C; a hydrogen thermometer fails above 500° C; and a nitrogen thermometer above 1550° C; moreover at these high temperatures extraordinary precautions are necessary if accuracy is to be secured. Thomson's accurate scale simplifies all this, and besides in the working out of its principles forms one of the a b c's in the laws of radiation—matters which are, however, all too deep for the unscientific mind.

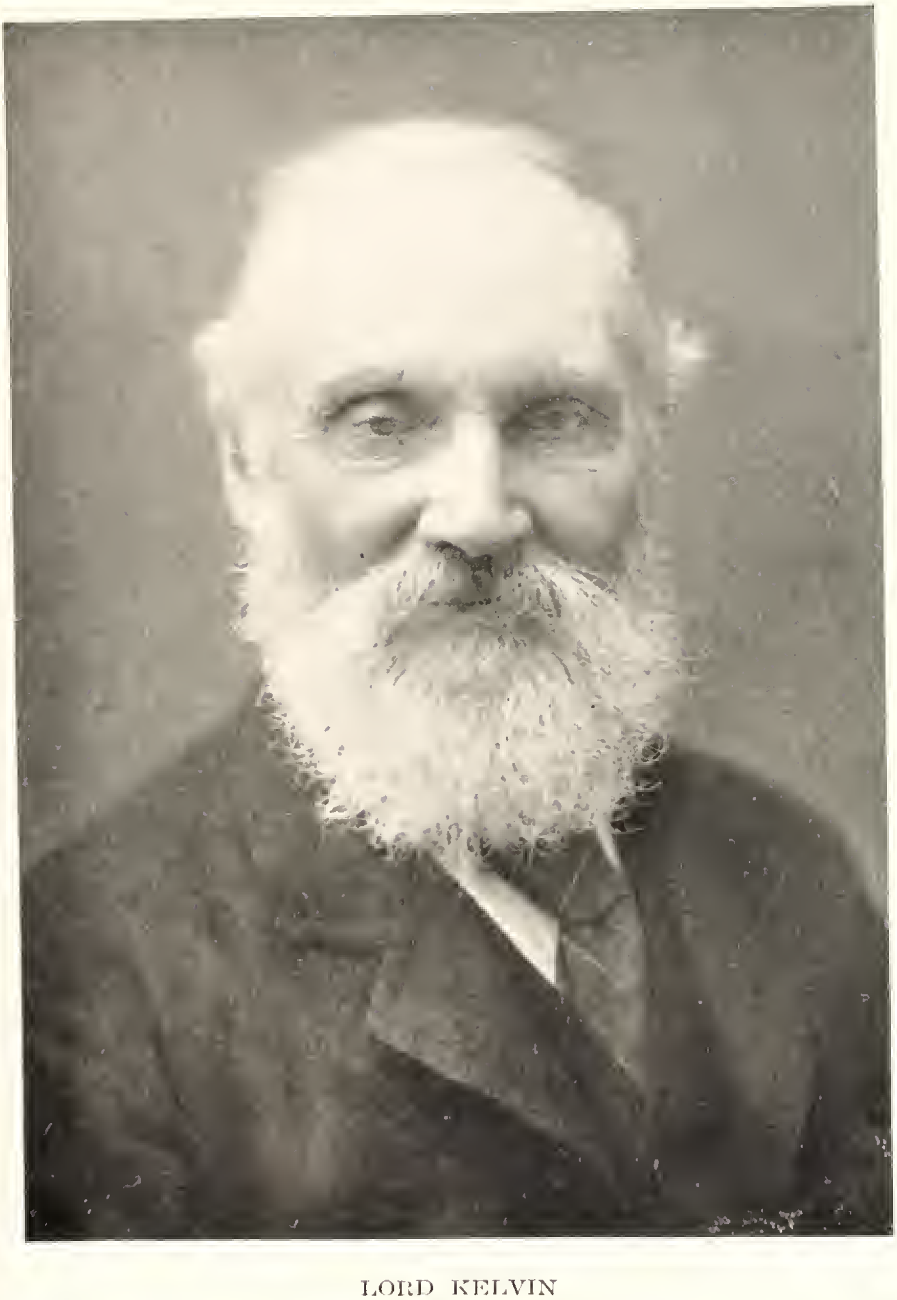
Since William Thomson was deeply interested in all the vital problems of his day, it was inevitable that he be drawn into the discussion concerning the feasibility of a telegraphic communication between England and America. In 1850, an experimental line had been laid between Dover and Calais, the cable used being a copper wire insulated by gutta-percha. In the try-out the signals received were characterized as "extraordinarily sluggish"; and within two hours all communication was at an end, owing to the line having been severed by the anchor of a fishing-smack. Of course the latter difficulty was easily remedied by using a stouter cable; but what was necessary to clarify the signals?

Hart, in his "Makers of Science," tells us that in the general discussion which followed, "The fact soon emerged that such a cable was really in effect an elongated Leyden jar of great capacity, the copper acting as the inner lining, the salt water as the outer lining, and the gutta-percha as the "glass" of the jar; and when a battery is connected up to one end of the core, the "Leyden jar" gradually gets charged up, first at the battery end, and gradually farther and farther along the wire, and so to the other end; and similarly when the battery is withdrawn (or the circuit broken), the discharge is equally gradual."

Nevertheless, a proper application of the general principle was lacking, and then it was that William Thomson. in May, 1855, appeared before the Royal Society with a paper entitled "On the Theory of the Electric Telegraph." The retardation of the electric impulse along a cable, he said, was proportional to the capacity and the resistance of the cable, and each of these quantities was proportional to the length to such an extent that the time retardation of a signal was in actual practise proportional to the square of the length. Thus, he illustrated, "If a cable 200 miles

long showed a retardation of $\frac{1}{10}$th second, one 2,000 miles of similar thickness would have a retardation 100 times as great, or ten seconds." Applying these proportions to the length of a trans-Atlantic cable showed such enormous difficulties to be overcome that the feat seemed well-nigh impossible. Thomson, however, was not without a solution for the most overwhelming of the problems. Employ a copper cable of the lowest resistance possible, and consequently of the highest conductivity, and use the thickest cross-section obtainable, he said in effect. Though there were many scoffers and objectors, so great was William Thomson's reputation as a practical physicist that his theories and opinion at once carried great weight, and very shortly plans were laid for the forming of the Atlantic Telegraph Company, with Thomson as chief director.

Subsequently a cable was successfully laid, and then began a struggle to register the signals, for these were so weak that all ordinary methods were of no avail. Thomson's solution was the invention of the celebrated mirror galvanometer, which is today considered an essential part of the equipment of every scientific laboratory. It was simple enough in its initial appearance. To the magnet at the center of the coil of an ordinary galvanometer Thomson attached a spherical mirror in such a manner that it hung suspended vertically, and of course swung with the magnet whenever a current passed round the coil. A spot of light from a lamp was reflected from this mirror on to a distant scale, and the scale being placed sufficiently far away, a tiny movement on the part of the mirror caused a very noticeable swing of the spot along the scale, and thus proved exceedingly sensitive to even the smallest current changes. By its action the feeble cable currents received were successfully recorded, and it seemed that the problem was solved. But alas!



LORD KELVIN
From a photograph

when the tide of rejoicing was at its highest, the messages ceased, and all efforts to revive the cable failed. However, the project could not be regarded as a failure. More than seven hundred messages, some of them of great importance, had been flashed from continent to continent, and what had been done could be done again.

"We must build a new and better cable," said Thomson, and forthwith busied himself with the plans, arranging to have a cable ship, the *Great Eastern,* carry the whole length of cable required, and to equip it for the freedom of manœuvring which would be required in the laying operations. Two attempts were necessary, however, before a successful line was laid, in 1866, and then the original cable was taken in hand and made serviceable. As electrical engineer to the expedition, and the one man more than any other who had counted towards its success, William Thomson was knighted, and on his return to his home city was received with triumphal rejoicing and befitting honors.

Thomson was not altogether pleased with the results accomplished by the mirror galvanometer. He thought he could better this, and eventually replaced it with the siphon recorder, a much more highly sensitive mechanism which is in use to this day. In Gray's "Lord Kelvin," occurs the following description of this first siphon recorder: "A small and delicate pen was formed by a piece of very fine glass tube in the form of a siphon, of which the shorter end dipped in an ink bottle, while the other end wrote the message in little zig-zag notches on a ribbon of paper drawn past it by machinery. The siphon was moved to and fro by the signalling currents which flowed in a small coil hung between the poles of an electromagnet, excited by a local battery, and the ink was spurted in a succession of fine drops from the pen to the paper. This was accomplished by electrifying the ink-bottle and ink

by a local electrical machine, and keeping the paper in contact with an uninsulated metal roller. Electric attraction between the electrified ink and the unelectrified paper thus drew out the ink drops, and the pen, which never touched paper, was quite unretarded by friction."

Being attracted to the commercial side of telegraphic engineering, Thomson went into the business with two partners, and to their activities were due many of the inventions which subsequently brought submarine telegraphy to pronounced recognition everywhere. His work on ocean cables, of course, brought Thomson into contact with the urgent problems which beset the science of navigation, and it is characteristic of the practical physicist that he could not rest until he had had a try at their solution, nor is it perhaps a matter for surprise that here as elsewhere he achieved great things.

Among the first of these inventions was a sounding-machine—an instrument specially needed in cable-laying, as the methods for deep sea sounding then in vogue were not only very primitive but exceedingly laborious. It consisted simply in stopping the ship until a sinker could be lowered at the end of a rope, then hauled up again and the paid-out line measured. It took several hands, and a nerve-racking waste of time. "Why couldn't pianoforte wires take the place of rope?" cogitated Thomson, and he accordingly busied himself with a scheme for a winding machine, and a sounder in the form of a cylindrical sinker, which he proposed to fit with a long glass tube lined with chromate of silver. The salt sea-water would react chemically on the chromate of silver producing a discoloration, and the depth of discoloration on the tube could be computed by scale to serve as an accurate measure of the depth of the sea. So much for the idea; but its practical application took no little pondering and experimentation. It is recorded that Joule seeking out

the inventor, one day, found him surrounded with pianoforte wire, and asked what purpose it was expected to serve. "Sounding," said Thomson, briefly. "What note?" queried Joule, not a little puzzled. "The deep C," was Sir William's quick and witty rejoinder.

Today his sounding device, with its steel cable usually made up of seven strands and 300 fathoms in length, is universally in use. "Heave Thomson over!" is the command of the navigation officer whenever the depth of the sea is desired, and how often has this faithful sounder kept a ship from going beyond its depth, or running aground in disaster. If the inventor had gone no farther, sailors everywhere would rise up to bless his name. But his sounding device was only a beginning. Being asked to write an article on the mariner's compass for a technical journal, Sir William found that he really knew very little about it, and on going into the subject was surprised to find how faulty in construction were the ones then in use. The needles were heavy and often fifteen inches in length, and mounted on large cards for steadiness, but the effect secured was frequently entirely the opposite: in fine weather the compass often stalled and in stormy weather it was practically useless. How could it be remedied? Thomson scanned the pioneer work on the theory of compass deviation, and presently he was satisfied that shorter needles mounted on a lighter card would be more satisfactory. "For," said he, "a slow horizontal swing will avoid unsteadiness, besides lessening the amount of friction to prevent sticking." Also he realized that it was essential to shield the compass from the magnetism of the ship's ironwork. Having settled on the various defects, Thomson was soon enabled to produce a mariner's compass which eventually came into almost universal use, though today it is being replaced by a new invention—the gyro-compass.

A sounding-machine and a mariner's compass, and both of such merit as to sweep all others before them, might have been deemed by some sufficient services for "those who go down to the sea in ships." But not so Sir William Thomson. He next turned his attention to the lighthouses, and suggested a system of distinctive lights to distinguish one from the other. Then followed a study of the tides and a tide-predicting machine, and some mathematical investigations concerning waves in general, together with some designs for the general betterment of ship-building. Small wonder, indeed, that in many quarters there should rise a rapidly growing sentiment much the same as that voiced by a sailor in the distant waters of the East: "I don't know who this Thomson may be, but every sailor ought to pray for him every night."

In 1892, Queen Victoria, wishing to place the stamp of the Crown's approval upon Sir William Thomson's zeal in behalf of applied science, raised him to the peerage, and he took the title of Lord Kelvin, thus perpetuating the name of the Kelvin river, whose placid waters idled near to the new university buildings at Glasgow. Honors from governments, scientific societies, and universities came to him from all over the world. He was president of the London Royal Society for five years, and of the Edinburgh Royal Society four times. In 1896 all Glasgow united in doing him honor for having completed a half-century of illustrious service as Professor of Natural Philosophy at its University. There were present representatives from all the great governments and scientific bodies, and the event was one of marked demonstrative sincerity, for Lord Kelvin had come to typify all that was highest in a physicist: in him were combined the powers of mathematical reasoning, the inventive faculty, and the manipulative skill of the great experimentalist. Nor was

his zeal anywise abated in this his jubilee year; he saw ahead many new and untried paths, and he was as eager as a boy in their pursuit. For three years longer he stuck to his post, and then, in his seventy-fifth year, he realized that the time had come when he must give up his professorship. He was succeeded by Andrew Gray, a former student and assistant, who later wrote the very able biography of his great master entitled "Lord Kelvin."

Giving up his position at the University by no means meant that Lord Kelvin had retired from scientific research. Indeed, the very day in which his resignation was tendered saw him enrolled as a special student in the experimental department, and he plunged into all sorts of tests and caculations with a freshness which quite astonished even those who knew him best. So for eight years longer he ran on, hale and hearty, "except for occasional bouts of facial neuralgia," and then death claimed him, December 23, 1907. His grave is beside that of Sir Isaac Newton in Westminster Abbey. "And," says Gray, "there he sleeps well who toiled during a long life for the cause of natural knowledge, and served nobly, as a hero of peace, his country and the world."

In May, 1921, a great gathering of scientists assembled at the call of the Institute of Civil Engineers for the awarding of the newly-created Kelvin Medal, during the course of which Lord Balfour, the great philosopher and politician, spoke as follows concerning the life and genius of the famous physicist: "Lord Kelvin had in a manner hardly, and perhaps never, equalled before, except by Archimedes, the power of theorizing on the darkest, most obscure, and most intimate secrets of Nature, and at the same time, and almost in the same breath, carrying out effectively and practically some engineering feat, or carrying to a successful issue some engineering invention. He was one of the leaders in the movement which has com-

pelled all modern engineers worthy of the name to be themselves men not merely of practice, but of theory, to carry out engineering undertakings in the spirit of true scientific inquiry and with an eye fixed on the rapidly growing knowledge of the mechanics of Nature, which can only be acquired by the patient work of physicists and mathematicians in their laboratories and studies."

THOMAS HENRY HUXLEY

THOMAS HENRY HUXLEY was himself the best exponent of his belief that "Science and Literature are not two things, but two sides of one thing." He combined the talents of the naturalist and comparative anatomist with those of the man of letters, and the writings which set forth his researches and expoundings are models of clearness and accuracy. "Science is nothing but trained and organized common sense," he held. And putting forth what he had to say concerning its various departments and phases involved simply setting down exactly what he meant, neither no more nor no less, without confusion or obscurity. Proceeding on the Duke of Wellington's famous theory of style, viz; having something to say and saying it, Huxley went one step further, adding "and say that which has to be said in such language that you can stand cross-examination on each word." Always he sought for clearness and organization in his composition, and here his faculty and training as an anatomist and piece-worker helped him, enabling him to sift clearly a beginning, a middle, and an end, and to see beforehand a clear picture of what he wished to construct.

Like the majority of those who have climbed the ladder of fame and distinction, Huxley made his ascent by sheer force of character. "His essential characteristic," one of his admirers tells us, "was energy, which gave him imagination, enthusiasm, and power. It was his energy which enabled him to give himself a liberal education; and it was his energy again which kept alive his delight in debate. He was an intellectual athlete who joyed in com-

bat with a foeman worthy of his steel. Absolutely veracious himself, he was disgusted not only with outright falsehood, but perhaps even more by shifty evasion and ignorant assumption. Holding that 'the truth shall set us free,' he was bold and prompt in declaring the truth and in attacking error."

On the only occasion when Huxley visited the United States, he was much attracted by the busy tugboats tearing about over the broad waters in the harbor of New York. "They seemed to him," his son tells us in his interesting biography of the man of science and letters, "the condensation and complete expression of the energy and force in which he delighted." And with the captivating humor which always made him so companionable, he turned to the one nearest him, remarking: "If I were not a man, I think I should like to be a tug!"

Thomas Henry Huxley was born May 4, 1825, at Ealing, then a quiet little country village, but now a suburb of London. His father was a master in a large semi-public school. His mother, he tells us, "had no more education than other women of the middle classes in her day," but she had an excellent mental capacity, and "the most piercing black eyes that I ever saw in a woman's head." She was particularly famed for swift arrivals at conclusions—a peculiarity which Huxley whimsically observed "had been passed on to him in full strength," sometimes standing him in good stead, but often playing him sad tricks, and always forming a danger he must combat. "But," he adds, "there is nothing I would less willingly part with than my inheritance of mother wit." From his father, young Thomas Henry got an inborn faculty for drawing—which he developed but slightly—a hot temper, and "a tenacity of purpose which unfriendly observers sometimes call obstinacy. . . . Why I was christened Thomas Henry," he records, "I do not know;

but it is a curious chance that my parents should have fixed for my usual denomination upon the name of that particular Apostle with whom I have always felt most sympathy."

But little is known of his early life. "I have next to nothing to say about my childhood," he tells us. "In later years my mother, looking at me almost reproachfully, would sometimes say, 'Ah! you were such a pretty boy!' whence I had no difficulty in concluding that I had not fulfilled my early promise in the matter of looks." But there was a "distinct recollection of certain curls" of which he was vain, and of a conviction that he resembled a certain handsome, courtly gentleman who was the vicar of the parish, and "a god to the country folk." That he had some dramatic ability, coupled with the desire to "take off" others that is inherent in all lively children, is shown in a remembrance of "turning my pinafore wrong side forwards in order to represent a surplice, and preaching to my mother's maids in the kitchen as nearly as possible in Sir Herbert's manner one Sunday morning when the rest of the family were at church." Indeed, all his life Huxley had the attributes of a preacher, and when he stood in the pulpit or on the lecture platform, as he so frequently did, no man in ecclesiastical attire ever had greater sincerity and earnestness in faithfully setting forth the logic that filled him.

Apropos of this point let us consider one of his greatest sermons, "On the Advisableness of Improving Natural Knowledge," delivered at St. Martin's Hall, London, on the first Sunday evening in 1866. Speaking of that time, two hundred years before, when "this great and ancient city, took breath between the shocks of two fearful calamities: one not quite past, although its fury had abated; the other to come," he went on to discuss the two horrors and to say that it would have fared ill with him then to have

stood midst the wailing of the mourners of fifty thousand dead, and the woeful denunciations and mad prayers of fanatics, and proclaimed as he now did that the hypotheses of all London were wrong in accounting for these calamities: "That the plague was no more, in their sense, Divine judgment, than the fire was the work of any political or of any religious sect; but that they were themselves the authors of both plague and fire, and that they must look to themselves to prevent the recurrence of calamities, to all appearances so peculiarly beyond the reach of human control—so evidently the result of the wrath of God, or of the craft and subtlety of an enemy."

Today, he went on to state, science has learned "that pestilences will only take up their abode among those who have prepared unswept and ungarnished residences for them. Their cities must have narrow, unwatered streets, foul with accumulated garbage. Their houses must be ill-drained, ill-lighted, ill-ventilated. Their subjects must be ill-washed, ill-fed, ill-clothed." That the London of 1665 was such a city all present knew, and he pointed to the fact that the Eastern cities where the plague still abided were such cities. Because England had learned some of Nature's laws and partly to obey her, the plague was no more, but they yet had typhoid with them, and cholera was often their visitor. As their natural knowledge and obedience increased, he predicted, London would count her centuries of freedom from typhoid and cholera as she now did her freedom from the terrible plagues which had swooped upon her thrice in the first half of the seventeenth century.

Going further, he proceeded to prove that it is often difficult to distinguish between prominent events and important events; for example, "the origin of a combined effort on the part of mankind to improve natural knowledge might have loomed larger than the Plague and have

outshone the glare of the Fire. . . . It is very certain that for every victim slain by the plague, hundreds of mankind exist and find a fair share of happiness in the world by the aid of the spinning jenny. And the great fire, at its worst, could not have burned the supply of coal, the daily working of which, in the bowels of the earth, made possible by the steam pump, gives rise to an amount of wealth to which the millions lost in old London are but as an old song."

Many people, he pointed out, were "so intent upon trying to see what is above Nature, or what is behind her, that they are blind to what stares them in the face of her. . . . Natural knowledge is, in their eyes, no real mother of mankind, bringing them up with kindness, and, if need be, with sternness, in the way they should go, and instructing them in all things needful for their welfare; but a sort of fairy godmother, ready to furnish her pets with shoes of swiftness, swords of sharpness, and omnipotent Aladdin's lamps, so that they may have telegraphs to Saturn, and see the other side of the moon, and thank God they are better than their benighted ancestors."

Speaking for himself, he felt that if this were to be the end and aim of natural knowledge—and in this term he included the wide fields of mathematics, physics, chemistry, biology, zoölogy, geology, religion, etc.—he would just as soon be quietly chipping his own flint axe, after the manner of his forefathers, a few thousand years back. But the outstanding facts justified a greater belief. "I say," he cried enthusiastically, "that natural knowledge, seeking to satisfy natural wants, has found the ideas which alone can still spiritual cravings. I say that natural knowledge, in desiring to ascertain the laws of comfort, has been driven to discover those of conduct, and to lay the foundations of a new morality."

So diligently did Professor Huxley himself labor to

improve natural knowledge that he became a past master in all the sciences, and was largely instrumental in spreading the knowledge which marks the nineteenth century memorable, even though his actual school training was, as he tells us, "of the briefest." He was a slightly built lad, and the schoolmasters who fell to his lot unfortunately cared little for the intellectual and moral welfare of their pupils. "We were left to the operation of the struggle for existence among ourselves," he tells us, "and bullying was the least of the ill practices current among us." Numbered with the most cheerful recollections of these days, he says, was the memory of the "effectual licking" he had given a big lad after being mistreated until he could stand it no longer, and he announced as "the greatest shock of his life," a later occasion when a groom who had been sent with a horse for him, doffed his hat and proclaimed himself as that boy. Inquiries brought out a hard luck story, and Huxley was disposed to offer help, but true to his nature of always verifying information, he made some investigation first, and found that the young man had not only been "sent out" once, but that he had undergone imprisonment for various minor offenses. In the parlance of Noah Claypole, " 'E was a regular bad 'un!"

As a lad Huxley's greatest desire was to become a mechanical engineer, "but the fates were against this," and so he commenced the study of medicine, "under a medical brother-in-law." He was still but a mere boy, thirteen or fourteen, and all unused to medical sights and smells when he was dragged off to his first post-mortem. Though he had ever been extremely sensitive to disagreeables, he tells us that so great was his anatomical curiosity that he spent two or three hours in gratifying it; then his weakness conquered and he was carried out with a stomach so sick that for years he "suffered from occa-

sional paroxysms of inward pain." Indeed, he records that, "From that time my constant friend, hypochondriacal dyspepsia, commenced his half century of cotenancy of my fleshy tabernacle."

Looking back in later life upon his "doings as a student," Huxley felt that an account of them would not "tend to edification. . . . I worked extremely hard when it pleased me," he tells us, "and when it did not—which was a very frequent case—I was extremely idle (unless making caricatures of one's pastor and masters is to be called a branch of industry), or else wasted my energies in wrong directions. I read everything I could lay hands upon, including novels, and took up all sorts of pursuits to drop them again quite as speedily." There was one period, however, to which he could refer with pride. While in attendance at the Charing Cross School of Medicine, he had one teacher whose "extent and precision of knowledge" impressed him so greatly that he was willing to go to great lengths to win his approbation, and he worked like a Trojan, being continually led onward by an inspiring instructor into laying foundations which were ever afterward to be of inestimable value.

He completed the Bachelor of Medicine course at the London University at the age of twenty-one, but being under the age required for entrance to the College of Surgeons, and forced also to the imperative necessity of earning his own bread, he began to look about him for an opening. "Why don't you write to the Director-General for an appointment in the Medical Service of the Navy?" queried a fellow student. The suggestion struck Huxley as being bold in the extreme, but in the end he followed it, and was rewarded by being asked to call on a certain date. The Director-General, "a tall, shrewd-looking old gentleman, with a broad Scotch accent," came in with young Huxley's card in his hand, and politely

returned it to him with the frugal reminder that he might find it useful on some other occasion. Then he surprised Thomas Henry by inquiring if he were Irish. "I suppose," Huxley afterward explained naïvely, "the air of modesty about my appeal must have struck him!"

But altogether the application evidently found favor with the Director-General, for shortly the young man found himself at Haslar Hospital for initiative training, under the direct supervision of "a very remarkable person . . . an excellent naturalist, and far-famed as an indomitable Arctic traveler." Huxley was kept busy on shore for about seven months, and was then assigned to the duties of assistant-surgeon on board the *Rattlesnake,* which shipped immediately on a long cruise where for many months the crew were "without receiving letters or seeing any civilized people" but themselves. In his autobiography, Huxley mentions that later he was often horrified to think how little he ever knew or cared about medicine as the art of healing. The only part of his professional course which had ever interested him was physiology, which he defined as "the mechanical engineering of living machines."

Fortunately there was small occasion to test his medical abilities, and the trip was really very engaging since it carried him into a part of the world of which he knew little, besides offering many opportunities for his already quickening interest in anatomical science. "It was good for me to live under sharp discipline," he tells us; "to be down on the realities of existence by living on bare necessities; to find out how extremely well worth living life seemed to be when one woke up from a night's rest on a soft plank, with the sky for canopy and cocoa and weevily biscuit the sole prospect for breakfast; and, more especially; to learn to work for the sake of what I got for

myself out of it, even if it all went to the bottom and I along with it."

During the four years of the cruise, Huxley learned many things, the results of which he sent home in "communication after communication to the Linnæan Society, with the same result as that obtained by Noah when he sent the raven out of his ark." Then, determined to win some sort of an acknowledgement, he set himself stoutly to the task, and succeeded in producing what he felt to be a really commendable paper. This he sent to the Royal Society, and "it *was* my dove," he tells us, "if I had only known it." But, owing to the erratic course of the ship, it was not until his return to England in the latter part of 1850, that he found his paper printed and published, and a huge packet of copies awaiting him. Apropos of this period, Huxley once said that when he heard some of his young friends complain of want of sympathy and encouragement, he was always inclined to think of his naval life, and to realize fully that it had really been a very valuable part of his education. It had, in fact, enabled him to give himself the truly liberal education he defined in one of his famous lectures:

"That man, I think, has had a liberal education who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine, with all its parts of equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as force the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; one who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a

vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself." [1]

The three years following Huxley's return to England were given over to a battle between his scientific friends and the Admiralty, as to whether the latter should live up to the spirit of a pledge they had given to encourage officers who had done scientific work by contributing to the expense of publishing his. In the end, the Admiralty settled the matter by curtly ordering him to join a ship, and this Huxley refused to do. He desired to obtain a position as professor of either physiology or comparative anatomy, and diligently applied wherever he could learn of vacancies, but without avail. Then, through the agency of friends, the Director-General of the Geological Survey offered him the position of paleontologist and lecturer on natural history. "I refused the former point blank," says Huxley, in his autobiography, "and accepted the latter only provisionally, telling Sir Henry that I did not care for fossils, and that I should give up natural history as soon as I could get a physiological post. But I held the office for thirty-one years, and a large part of my work has been paleontological."

It will thus be seen that Huxley had learned to do his own thinking, and to stand on his own feet. But he was entirely unaccustomed to speaking in public; moreover he felt that he simply could not do it, and his new post required that he be one of the regular speakers before the learned and critical body of the Royal Institution. What was to be done? He must simply overcome his repugnance, and force himself to act the part set for him. In due time, not only did the ordeal cease to be a bugbear, but he became an exceedingly clear and able speaker, never talking at random or indulging in flowery rhetoric,

[1] "A Liberal Education: And Where to Find It."

THOMAS H. HUXLEY.

but going straight to the point in what he had to say, delighting in aggressively setting forth the claims of science, holding "him who exploded old error next in rank to him who discovers new truth." He was ever ready to champion new beliefs, when he found them justified by facts, no matter how alone the theorist stood. Nor could he be overawed by authority; he felt that he had a right to inspect all the alleged evidence in support of a claim. "If any one tells me, 'it stands to reason' that some thing must be," he once said, "I generally find there is occasion to doubt the safety of his reason."

No searcher after truth ever had a greater regard for scientific integrity than Thomas Henry Huxley. The vein of this runs through all his research reports, and crops up continually in his lectures and addresses. "Veracity is the heart of morality," he upheld, and was wont to declare that the very air of the universities of the land should be "charged with an enthusiasm for truth." He had also a breadth of outlook far beyond what might have been expected from the general man of science—a largeness of vision due from his lifelong habit of reading everything he could lay hold of. "My father possessed a wonderful faculty for tearing out the heart of a book," Leonard Huxley declares, "reading it through at a gallop, but knowing what it said on all the points that interested him . . . how it fitted into his own scheme of knowledge, and where to find any point again when he wished to cite it." At the age of seventeen, when Huxley had won his free scholarship to the Charing Cross Medical College, his application stated that he had "a fair knowledge of Latin, read French with facility, and knew something of German." As the years progressed he continually added to his store of languages, until he perused at least a half-dozen different ones with ease, reading both ancient and modern authors. We are told that he "learned Greek in

mid-life mainly because he wanted to assure himself as to the exact meaning of a statement of Aristotle's." Brander Matthews, in speaking of Huxley's delight in browsing among books, refers to Bacon's well-known quotation that "reading maketh a full man, conference a ready man, and writing an exact man." Huxley, he continues, "was a full man, who was ever ready and always exact."

Huxley was a master of so many sciences that his real position is difficult to determine. "Notwithstanding that natural science has been my proper business," he tells us, "I am afraid there is very little of the genuine naturalist in me. I never collected anything, and species work was always a burden to me; what I cared for was the architectural and engineering part of the business, the working out the wonderful unity of plan in the thousands and thousands of diverse living constructions, and the modifications of similar apparatuses to serve diverse ends." His greatest original discovery directed the attention of science to protoplasm as the chemical and physical basis of life. He was the friend and champion of Charles Darwin in his theory of evolution, and suffered no little obloquy thereby.

His fellows workers, who constituted the ones most able to appreciate his merits, made him a member of the Royal Society before he was twenty-six, and promoted him to be their president while he was still in the fifties. They also awarded him the Copley, Linnæan, Wollaston, and Darwin medals. He held various positions of trust and honor in private life, serving on the first school board organized in London, and being a member of no less than ten royal commissions.

His writings were voluminous and very complete expositions of the scientific facts he sought to present; the same conditions applied to his lectures and addresses.

His lectures "A Lobster" and "The Crayfish" serve as delightful introductions to the study of geology; "On a Piece of Chalk" is an equally interesting opening to the fields of geology; "On the Method of Zadig" brings out what may be accomplished by clear thinking and careful construction. Zadig, that most admirable of detectives, created by one Arouet de Voltaire, has been characterized as "an elder brother" of the two most famous detectives in modern literature, Poe's Monsieur Dupin, in the "Murders in the Rue Morgue," and Conan Doyle's illustrious Sherlock Holmes. Huxley introduces the great Zadig and his famous line of conclusions to show that the methods employed by the man of science are only those of "trained and organized common sense." The clues which he must follow are not dissimilar in complex from those which enabled the great master detectives to solve their apparently inexplicable puzzles. They are the same, also, as those which enabled Leather Stocking to follow the trail of his Indian foes across the pathless plain and through the mazes of the forest. To read the methods of Zadig and their "rigorous application" is the first step in understanding what the great anatomist terms "retrospective prophecy as a function of science."

Paleontology, archeology, geology—all owe their foundation to the principles exposed. They are, as Huxley points out "retrospectively prophetic and strive towards the reconstruction in human imagination of events which have vanished and ceased to be," and the warp and woof of the whole fabric is cause and effect—logical conclusions borne out by trained thinking and common sense. Today, as Huxley prophesied, improved methods of the great pioneer detective are enabling the biologist more and more "to reconstruct the scheme of life from its beginning," and to speak as confidently of the character of long extinct living beings, no trace of which has been

preserved, as Zadig did of the queen's spaniel and the king's horse: "A very small spaniel; she limps with the left foreleg and has very small ears." "A first-rate galloper, small-hoofed, five feet high; tail three feet and a half long; cheek pieces of the bit of twenty-three carat gold; shoes silver." And Zadig, bear in mind, had seen neither spaniel nor horse! He had simply observed the marks of their progress through the forest.

Huxley's address on "Science and Culture," delivered before the members of the Liverpool Institute, in 1882, may be taken as an exhibition of his own breadth and culture and an example of his varied interests in letters, music, the fine arts, and the numerous sciences in which he excelled. A paragraph in "A Liberal Education," sets forth the "core of his creed," and explains the spirit which kept him ever in the arena: "It is a very plain and elementary truth, that the life, the fortune, and the happiness of every one of us, and, more or less, of those who are connected with us, do depend upon our knowing something of the rules of a game, infinitely more difficult and complicated than chess. It is a game which has been played for untold ages, every man and woman of us being one of the two players in a game of his or her own. The chessboard is the world, the pieces are the phenomena of the universe, the rules of the game are what we call the laws of Nature. The player on the other side is hidden from us. We know that his play is always fair, just, and patient. But also we know, to our cost, that he never overlooks a mistake, or makes the smallest allowance for ignorance. To the man who plays well, the highest stakes are paid, with that sort of overflowing generosity with which the strong shows delight in strength. And one who plays ill is checkmated—without haste but without remorse."

Toward the latter part of his life Huxley's health was

very poor and he was forced to retire to his home at Eastbourne, but for some time his ear was still tuned to scientific research and his love for reading and study remained with him to the last. He died, June 29, 1895, at the age of seventy years.